CSI PROJECT HIDDEN LAKE BASIN
PHASE 2 SUBREGIONAL PLANNING REPORTS

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Task 250: Refining Wastewater Service Alternatives (continued)

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King County Conveyance System Improvement Project
Executive Summary

The Conveyance System Improvement Project's Hidden Lake Service Area reports describe current and future wastewater planning issues and solutions for King County Wastewater Treatment Division (KC WTD) facilities located in the western part of the City of Shoreline. The Hidden Lake Service Area (Service Area) includes all sewered areas that drain to the KC WTD Hidden Lake Pump Station and all downstream neighborhoods that drain to the Boeing Creek Trunk and Richmond Beach Pump Station. Changes to the size and operations of the Hidden Lake Pump Station designed to fix its problems will also affect these downstream facilities.

Three sewer agencies own, operate and maintain wastewater conveyance facilities in the Service Area: the Shoreline Wastewater Management District (WMD), the Highland Sewer District (SD) and KC WTD. The Shoreline WMD and Highlands SD are responsible for collecting and transferring wastewater to KC WTD. KC WTD conveys local agency flows through a combination of force main and gravity sewer to the Edmonds Wastewater Treatment Plant for treatment and discharge. Figure 1 shows the extent of the Service Area, local agency boundaries, and major facilities.

The KC WTD facilities in the Service Area are the Hidden Lake Pump Station, the Boeing Creek Trunk and the Richmond Beach Pump Station. As shown in Figure 1, the Boeing Creek Trunk begins at the discharge of Shoreline WMD's 1,300-acre Basin 14. The trunk runs by gravity to the Hidden Lake Pump Station. The Hidden Lake Pump Station discharge is conveyed by force main and then by gravity through the Boeing Creek Trunk to the Richmond Beach Pump Station, and then by force main and gravity to the Edmonds Treatment Plant.

Background

The Boeing Creek Trunk and Hidden Lake Pump Station were built in the early 1960's. At that time, the newly formed Ronald Sewer District (now Shoreline WMD) was in the process of developing a sewer system. The Highlands SD was collecting wastewater from the 100 homes in the Highlands and discharging to Puget Sound. Over the past 40 years, the Service Area population has grown to 20,000, almost all of which is served by sanitary sewers. As the sewered population has grown and the sewer infrastructure has aged, a number of wastewater conveyance concerns have arisen:

- The pumping capacity of the Hidden Lake Pump Station and the hydraulic capacity of the Boeing Creek Trunk are insufficient to convey peak wet weather flows to the KC sanitary sewer standard of one overflow per 20 years (Figure 2). These capacity limitations result in overflows from the Hidden Lake Pump Station wet well and downstream at Boeing Creek Trunk manhole 7A (see Figure 1 for overflow manhole location). The electrical, instrumentation and control, and mechanical equipment in the Hidden Lake Pump Station are nearing the end of their useful lives. Mechanical failures result in overflows from the pump station wet well. Overflows due to capacity limitations and/or mechanical failures occur an average of three times per year at the Hidden Lake Pump Station.

- Sulfide-related corrosion and odors have been a problem at the Hidden Lake Pump Station and in the downstream piping. In 1988, sections of the Boeing Creek Trunk showing the most advanced corrosion were rehabilitated with HDPE sliplining. The sliplining reduced the inner diameters and hydraulic capacity of the rehabilitated sections of pipe by an estimated 1 to 3 mgd (see Figure 2, *Original Capacity* and *Current Capacity* for pre- and post-sliplining capacities).

- There have been backups into the local system from the Boeing Creek Trunk. Several houses located upstream of the Hidden Lake Pump Station experienced backups due to the limited capacity at the pump station. In 1997, these homes were disconnected from the Boeing Creek Trunk and rerouted via Shoreline WMD PS No. 5 to prevent basement flooding. In that same year, a backflow preventor valve was supplied by KC WTD and installed in the local sewer on NW 188th Street to eliminate further backups in this neighborhood downstream of the Hidden Lake Pump Station that same year.

The Service Area is largely developed and the future growth rate is expected to continue at a modest rate of less than one percent annually. Future growth will occur as vacant lots are filled in and neighborhoods adjacent to commercial corridors are rezoned to allow for higher density, multi-family housing. Wastewater planning for the Service Area is driven more by the need to address the immediate concerns of alleviating the operational difficulties at the Hidden Lake Pump Station, managing peak wet weather flows while anticipating the effects of future sewer deterioration, and controlling odor, rather than accommodating future growth. Any wastewater service improvement plan must also include enough flexibility to work with the results of the North Plant siting study and the KC regional infiltration and inflow (I/I) study. These projects will help refine the projected peak design flow, the costs and feasibility of I/I reduction, and the most efficient means of wastewater routing.

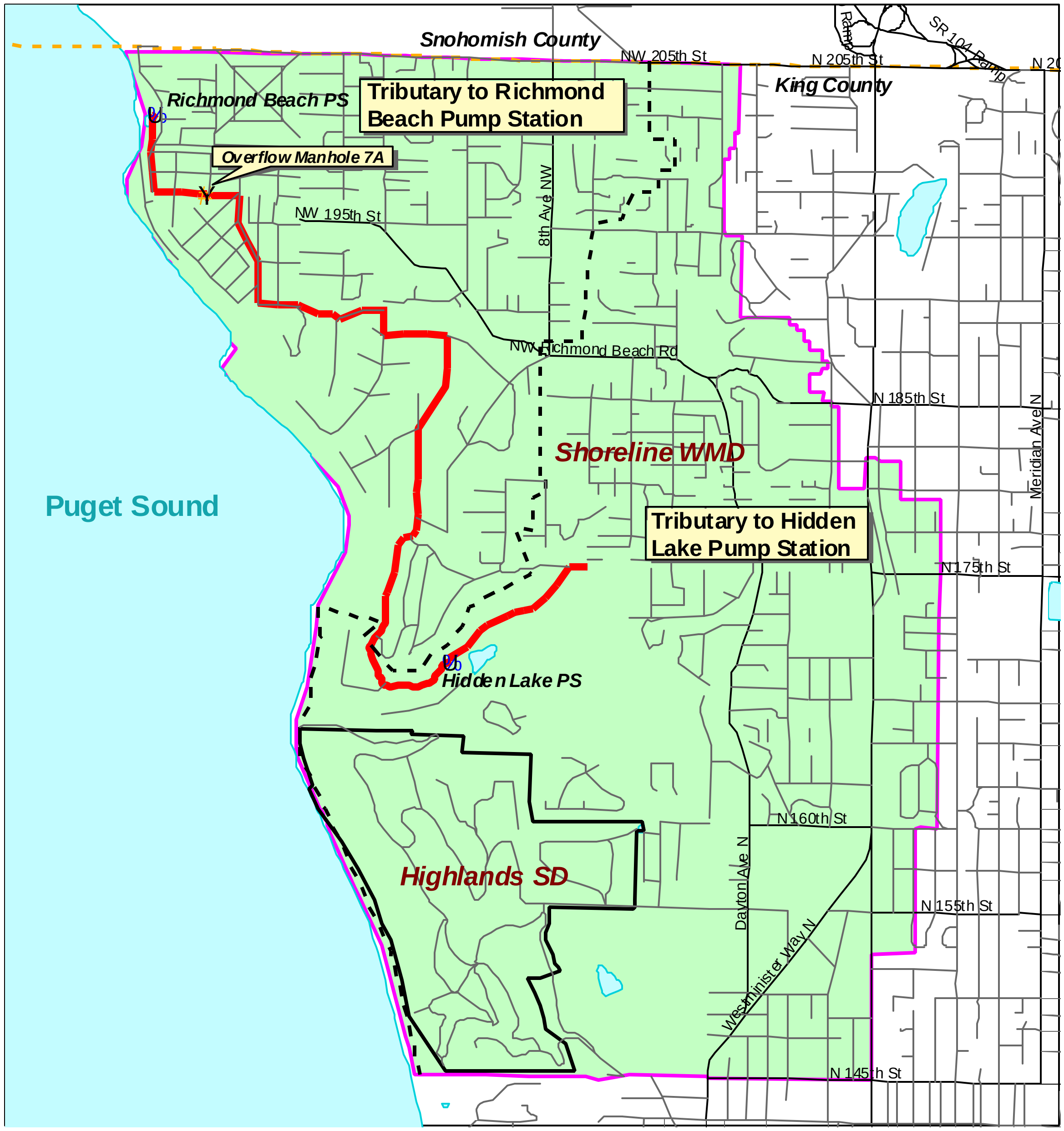

Figure 1: Hidden Lake Service Area

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May 11, 2000

Legend

- County Boundary
- KC Pump Stations
- Boeing Creek Trunk
- Hidden LK Service Area

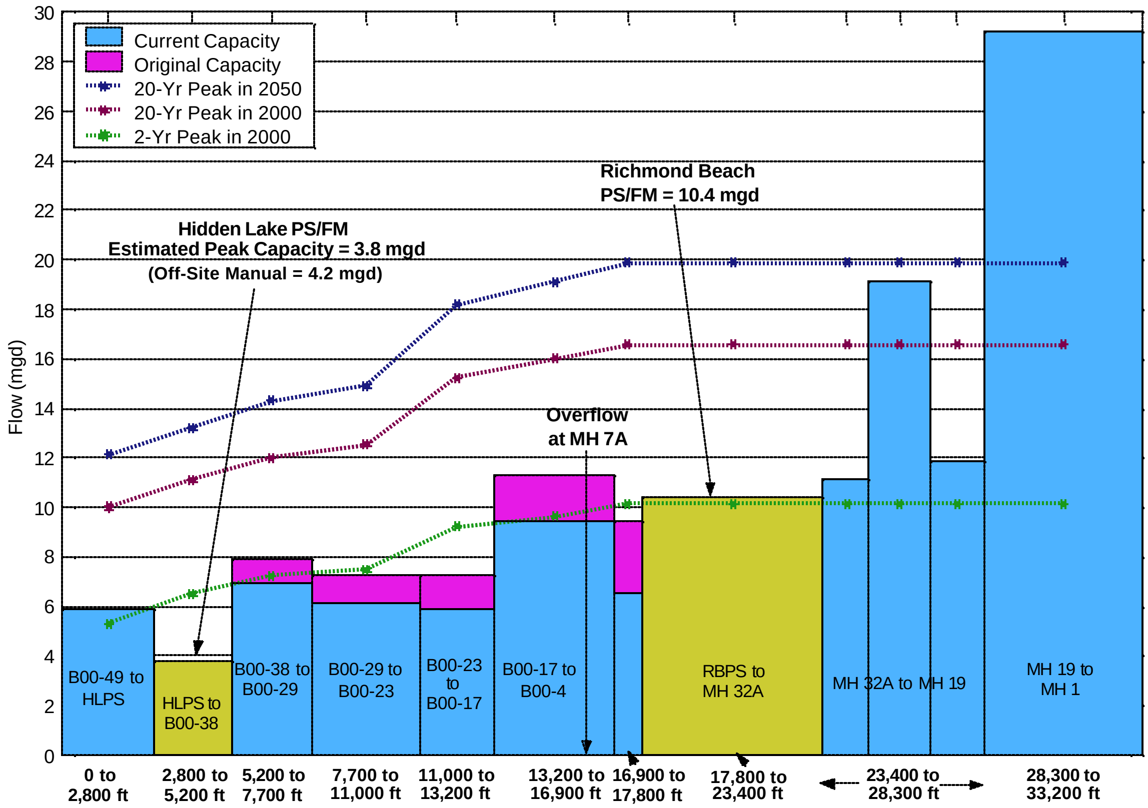

Figure 2. Peak flows and conveyance capacity in the Boeing Creek Trunk.

Conveyance System Improvement Alternatives

The CSI project team developed 15 alternatives and sub-alternatives for reducing the number of Service Area overflows to the King County standard of once per 20 years. All of the alternatives include provisions for replacing or retrofitting the Hidden Lake Pump Station and thus addressing the reliability and odor control problems at the station. The alternatives, which are fully described in Task Memos 240 and 250, are composed of combinations of the following elements:

1. Upgrading the capacity of the KC WTD pump stations and sewers along present routing.

2. Using storage to attenuate peak flows and control system overflows.

3. Diverting peak wet weather flows away from the Boeing Creek Trunk.

4. Targeted infiltration and inflow (I/I) reduction

The description of each alternative addresses replacement, upgrading, and/or construction of new King County facilities. Construction factors, planning and permitting issues, and impacts on other King County facilities also were described and planning level cost estimates were developed. Wherever new facilities were required, they were sized using the flow projections provided by KC WTD for the year 2050. The KC WTD flow projections were based on population forecasts (used to compute sanitary base flow) and the results of the calibrated KC WTD hydrologic I/I model.

During the process of developing alternatives, the CSI project team engaged King County staff for evaluation and input. The following sections describe the key elements of the various alternatives and the input of the CSI project team and KC Staff (see Table 1 for a summary of the results).

The Shoreline WMD was consulted throughout this planning study. The District's review included draft reports for Task 210, 220, 230, 240, 250 260, and an early proposed draft 310. The District also attended meetings in November 1999 and again in April 2000. The final Task 250 and 260 reports include additional information and appropriate clarification as provided by the District their its engineer's May 5, 2000, letter to King County.

Task 240 Review

The CSI project team and KC WTD staff met at a project workshop on August 19, 1999, to discuss the nine alternatives and sub-alternatives presented in the Task 240 report. All agreed that paralleling the Boeing Creek Trunk (Alternative A) or incorporating tank storage into the system (Alternatives B1 and B2) would not be the best choices for a number of constructability and operations reasons. For example, County staff was concerned with the difficulties associated with constructing a parallel sewer through the Innis Arden neighborhood due to the number of existing buried utilities. KC staff also raised operations and maintenance concerns regarding storage.

The CSI project team and KC staff similarly agreed that the selection of diversion alternatives, collectively known as Alternative D, were generally not feasible, again for a variety of technical and/or operations reasons. Alternatives D1 and D2 were not considered feasible because each would redirect peak wet weather flows into sections of the KC WTD conveyance system that already have conveyance capacity limitations (D1 – Lake Ballinger Pump Station; D2 – North Lake City Trunk/Matthews Park Pump Station). There are hydraulic advantages of constructing a sewer along the waterfront (Alternative D3), but workshop participants were concerned about the potential environmental impacts of constructing a pipeline down to the bluff and along the waterfront. (A subsequent environmental review in Task 250 identified an unacceptable number of difficult permitting issues with Alternative D3.) The number of receiving pits required to follow the public right of way along NW 175th Street and the potential inconvenience to local residents were noted shortcomings of tunnel Alternative D4.

The workshop consensus was that Alternative C2 was the most feasible alternative. Alternative C2 would include a 13.2 mgd pump station located at the beginning of the Boeing Creek Trunk that would divert peak wet weather flows in a new force main/gravity sewer northward towards the Edmonds Wastewater Treatment Plant (or to the planned North Treatment Plant, once it is operating). The diversion would be large enough to avoid construction along the existing trunk. The Hidden Lake Pump Station would be rebuilt at a similar size with bidirectional pumping so that dry weather flows could be sent to the Boeing Creek Trunk to aid in operation of the inverted siphon and Richmond Beach Pump Station.

Task 250 Review

The project team held a meeting with KC staff on December 2, 1999, to discuss refinements to what was then the working alternative, Alternative C2 (diversion pump station and sewer). County staff felt all possible improvements had not been examined and that given the level of capital expense in Alternative C2, additional alternatives should be developed. There was also direction to examine a phased project implementation that could successfully coordinate with ongoing King County projects in the area, and level capital costs. A total of five additional alternatives were evaluated and compared against Alternative C2. Of these, Alternatives D8 and D9, which each incorporate phased construction and a combination of overflow control strategies, were considered the most feasible. The consultant team set out to develop a broader set of phased/combination alternatives to present to KC Staff in order to arrive at a working solution to pass along to the County's Capital Improvement Projects group. Table 1 gives a synopsis of each of the alternatives and sub-alternatives considered, along with conclusions about their feasibility.

Table 1. Summary of Hidden Lake alternative analysis

Alt. No.	Description	Team Action	Reason
A	Capacity upgrades using existing alignment	Modified	Complete upgrade rejected because of construction difficulties due to existing buried utilities in right-of-way, but some segments might be upgraded without utility complications
B1	2.4 MG storage at Hidden Lake Pump Station	Rejected	Tank siting problems, higher cost, higher O&M requirements
B2	1.5 MG storage at Richmond Beach Pump Station	Rejected	Does not avoid construction difficulties noted for Alt. A; probability of piling to support tank drives up cost
C1	Diverting flow from Hidden Lake PS with 9.7 mgd pump station	Rejected	Higher cost than C2 because it requires a new pump station plus upsizing Boeing Creek facilities
C2	Diverting flow from Hidden Lake PS with 13.2 mgd pump station	Working Alternative	Lowest cost alternative because a larger pump station eliminates need to upgrade Boeing Creek facilities
D1	Pump flow to Lake Ballinger PS	Rejected	Transfers wet weather flows to other maximized/optimized King County conveyance facilities
D2	Pump to North Lake City Trunk and Matthews Park basin	Rejected	Transfers wet weather flows to other maximized/optimized King County conveyance facilities
D3	New sewer over bluff and along shoreline to Edmonds WWTP	Environ. Evaluation	Gravity option a plus, but environmental concerns (ESA, sensitive areas) limit viability
D4	Tunnel new pressure sewer under NW 175th St.	Rejected	Tunnel would be long, deep and have many turns, driving up costs
D5	Use old primary clarifiers at Richmond Beach for storage	Rejected	Storage capacity in clarifiers Insufficient to significantly lower costs relative to Alts. A & B2
D6	Direct part of Basin 14 flows out of Service Area	Rejected	Reduces size of Hidden Lake pump station, but requires long, deep directional drilling
D7	Tunnel storage and conveyance	Rejected	Would require difficult tunnel easements under private property; limiting tunnel to public r-o-w not feasible because of number of street turns
D8	Short term solutions to reduce overflows until North Treatment Plant built	Working Alternative	Controlling 2 year storm requires significant investment now with greater investment required later, but underutilized facilities are avoided and flexibility is maintained
D9	Phase construction on as-needed basis, waiting to see how regional I/I program, North Treatment Plant impact basin	Working Alternative	Can be used with working alternative C or any other alternative to eliminate costs that might not be needed if these programs reduce Hidden Lake problems

Working Alternative

A set of phased/combination alternatives was presented to KC staff at a decision workshop held on March 16, 2000. The objective of the workshop was to specify a working alternative that would meet the immediate upgrade needs at the Hidden Lake Pump Station, reduce the number of sanitary overflows in the service area, and achieve the KC 20-year storm control level.

The working alternative will initially retrofit or replace the Hidden Lake Pump Station to achieve a peak pumping capacity of 5.5 mgd, and parallel or replace a total of 6,400 lineal feet of the most capacity limited sections of the Boeing Creek Trunk[1]. Increasing the pumping capacity at Hidden Lake and removing the bottlenecks in the Boeing Creek Trunk would allow the full capacity of the Richmond Beach Pump Station to be used. This combination of upgrades will reduce the number of storm related overflows to approximately one every 2 years. Providing 0.5 MG of storage upstream of the Hidden Lake Pump Station will, according to the best available flow information, further reduce the number of storm related overflows to one every 4 to 5 years. After the North Plant siting and regional I/I programs are completed (assumed 2005), the level of control will be brought to the KC standard of one overflow every 20 years by I/I reduction, additional storage and/or construction of a diversion pump station and sewer directed away from the Boeing Creek Trunk. The final flow projections developed during the regional I/I study, and the North Plant location would be used for final sizing and alignment of the new facilities.

The paralleling/replacement work is planned for the pipe segments between manholes B00-29 to B00-17 and B00-7 to the Richmond Beach Pump Station (Figure 3). These pipes are shown in Figure 2 as not having enough capacity to pass the 2-year peak flow. Wherever it is feasible, replacing capacity limited pipes should supersede the County's planned corrosion-related rehabilitation of the Boeing Creek Trunk.

The CSI project team performed a preliminary siting analysis for the 0.5 MG of storage facility. One potential location for offline, gravity in/out storage is along NW 175th Street, between 6th and 10th Avenues NW at the upstream end of the Boeing Creek Trunk. A storage tank and associated piping could be located on a section of the vacant property on the northwest corner of NW 175th Street and 6th Avenue NW. Alternatively, a 1,450 lineal foot, 8-foot diameter offline pipe could be installed from B00-49 to B00-42 to provide 0.5 MG of storage upstream of the Hidden Lake Pump Station (Figure 3). The location and alignment of storage elements must be examined during project predesign.

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[1] Increasing the capacity of the Hidden Lake Pump Station from 3.8 mgd to 5.5 mgd and upgrading the downstream conveyance brings the capacities of these facilities in line with the Richmond Beach Pump Station. Both upgrades are essential to reducing overflows until the 20-year control plan is implemented. Increasing the capacity of the trunk sewer will reduce overflows at manhole 7A (located near the Richmond Beach Pump Station; see Figure 1 for manhole location). Rebuilding or retrofitting the Hidden Lake Pump Station with a 5.5 mgd capacity will reduce the frequency of overflows from the wet well, while limiting force main velocities to 8 ft/s. All facilities would have sufficient capacity for the unattenuated 2-year peak flow.

This selected system alternative provides:

- Short-term improvements that will reduce the frequency of overflows and long-term improvements will incorporate better flow projections and routing information.
- Time for the regional I/I program to work. Rather than accepting all flows from the component agencies, the County can work with these agencies to promote I/I reduction and system maintenance to reduce peak flows.
- Expanded capacity in the Boeing Creek Trunk that will allow the Richmond Beach Pump Station to be fully utilized.

Table 2 and Figure 4 show cost estimates for both phases of the working alternative. The phase II costs assume additional facilities are a diversion pump station and sewer sized to provide enough additional capacity to convey the 20-year peak flow.

Table 2. Working Alternative cost estimate

	Cost (millions; ENR Seattle CCI =7,000)
Project Phase I:	
Replace Hidden Lake PS at 5.5 mgd	3.3[a]
Parallel/Replace 6,400 ft of Boeing Creek Trunk (brings control to 2-year level)	4.0[a,b]
Add 0.5 MG of storage upstream of Hidden Lake PS (brings control to 4 to 5-year level)	2.8[a]
Add KC allied costs (assume +50%)	+50%
Phase I Total	**15.1**
Project Phase II:	
Add facilities (brings control to 20-year level; KC allied costs included)[c]	20.5
Total Project Cost:	**35.6**

a. Brown and Caldwell estimates include 10% contractors O&P, 10% mob/demob, 30% contingency, 8.6% sales tax, and 35% for design. These costs assume the Hidden Lake Pump Station is replaced, not retrofitted.

b. Construction costs in the congested area downstream of the Hidden Lake Pump Station have been increased by 50% to reflect the potential difficulties of design and construction in areas with large numbers of buried utilities.

c. Assumes diversion pump station and sewer sized to bring control to 20-year level with no I/I reduction, and a 7% increase in I/I per decade for 3 decades through 2030.

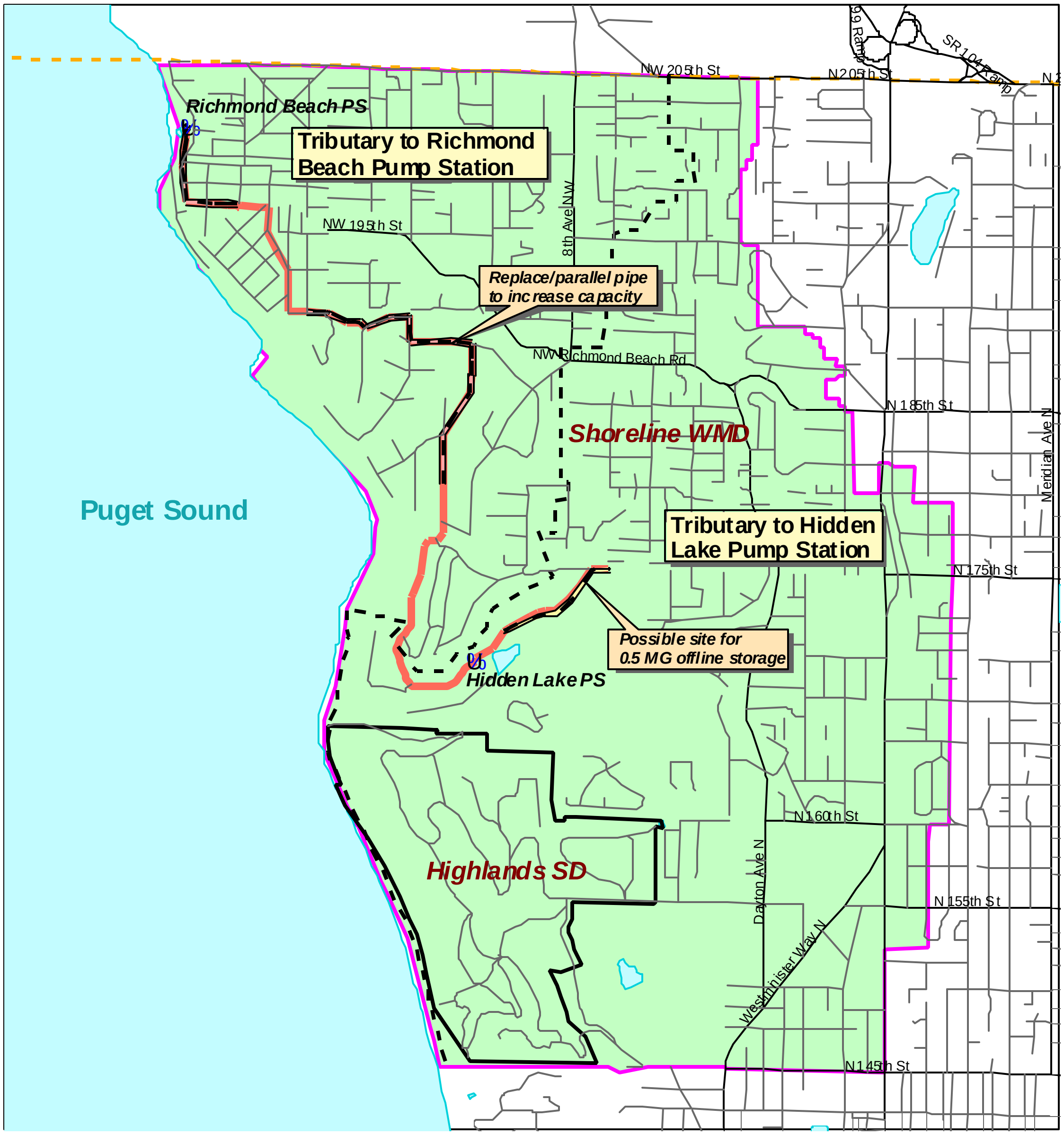

Figure 3: Working Alternative Phase I

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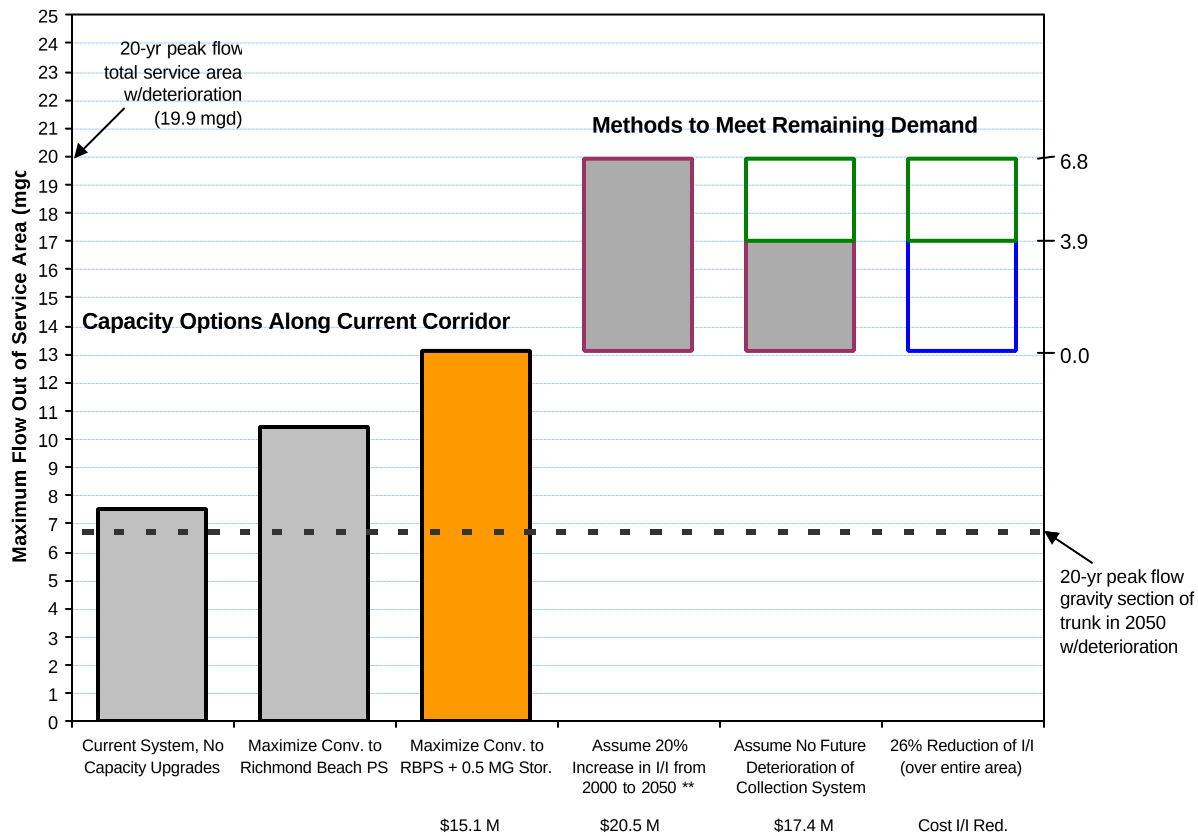
May 11, 2000



**** 7 percent per decade I/I increase through 2030**

Figure 4. Distribution of costs for interim and future facilities upgrades in the Service Area

KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT

TASK 210

HIDDEN LAKE SERVICE AREA PLANNING RECORD SUMMARY

HIDDEN LAKE SERVICE AREA
TASK 210: PLANNING RECORD SUMMARY

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INTRODUCTION

The results of our review of planning records for the Hidden Lake Service Area dating back to the 1958 Metropolitan Seattle Sewerage and Drainage Survey (1958 Plan) are presented in this memorandum. A description of the planning area and present conveyance issues is followed by a discussion of the development of wastewater services, the impacts of future growth and the implementation of the King County's Regional Wastewater Services Plan (RWSP).

General Planning Area Description

The Hidden Lake Service Area is located in Northwest King County in the city of Shoreline (Figure 1). The King County Wastewater Treatment Division (WTD), Shoreline Wastewater Management District (WMD), and Highlands Sewer District (SD) each own and maintain elements of the wastewater conveyance system within the service area. Because of the nature and scope of conveyance issues in the study area, the Hidden Lake Service Area has been defined to include areas draining to the Hidden Lake Pump Station and all areas contributing to wastewater flows in the King County conveyance system upstream of the Richmond Beach Pump Station (Figure 2).

King County WTD's Hidden Lake Pump Station, located at the intersection of NW Innis Arden Way and NW 167th Street receives wastewater flows from King County WTD and Shoreline WMD sewers. From areas north and east of the pump station, sanitary flows are carried by gravity sewers, intercepted by King County's Boeing Creek Trunk (NW 175th Street and 6th Avenue), and delivered to the pump station. Shoreline Pump Stations No. 4 and No. 5 also discharge to the Hidden Lake Pump Station. Shoreline Pump Station No. 5 receives most of its influent from the Highlands Sewer District. The total drainage area of the Hidden Lake Pump Station is 2.9 square miles (sq. mi.) (1,850 acres).

The Hidden Lake Pump Station has a documented firm pumping capacity of 4.2 mgd, but under actual operating conditions the capacity is probably closer to 3.8 mgd (Ed Cox, personal communication). An 18-inch diameter overflow line leads to Shoreline Pump Station No. 4 where wastewater can be temporarily stored, pumped back to the Hidden Lake Pump Station, or discharged 365 feet to a marine outfall. The Hidden Lake Pump Station discharges to a 2,375-foot long 14-inch diameter force main section of the Boeing Creek Trunk. Downstream of the force main, gravity sewers and a siphon carry wastewater flows to the Richmond Beach Pump Station. There are numerous interconnections between Shoreline WMD sewers and the gravity section of the Boeing Creek Trunk, adding flows to the system downstream of the Hidden Lake Pump Station.

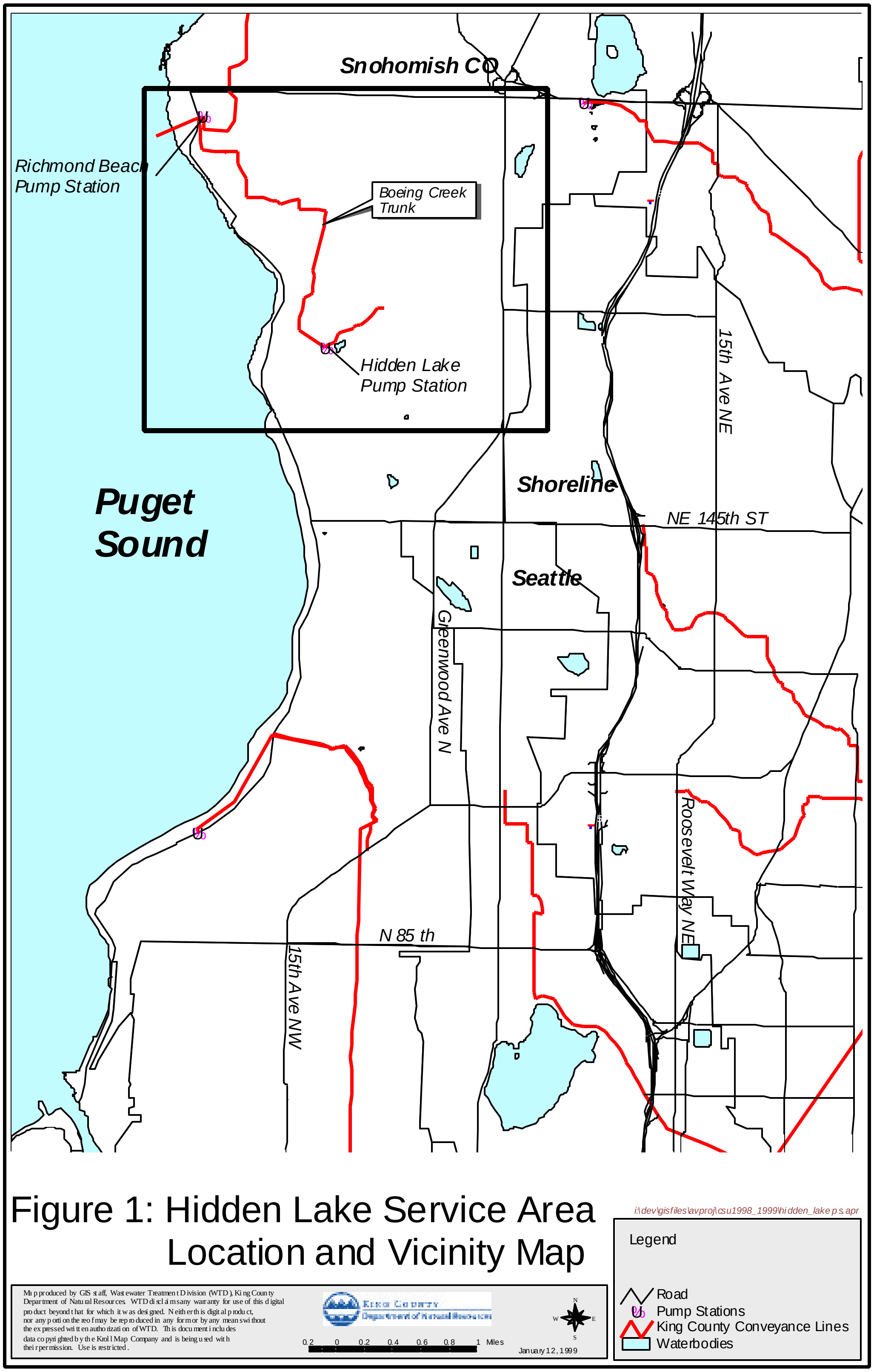

Figure 1: Hidden Lake Service Area Location and Vicinity Map

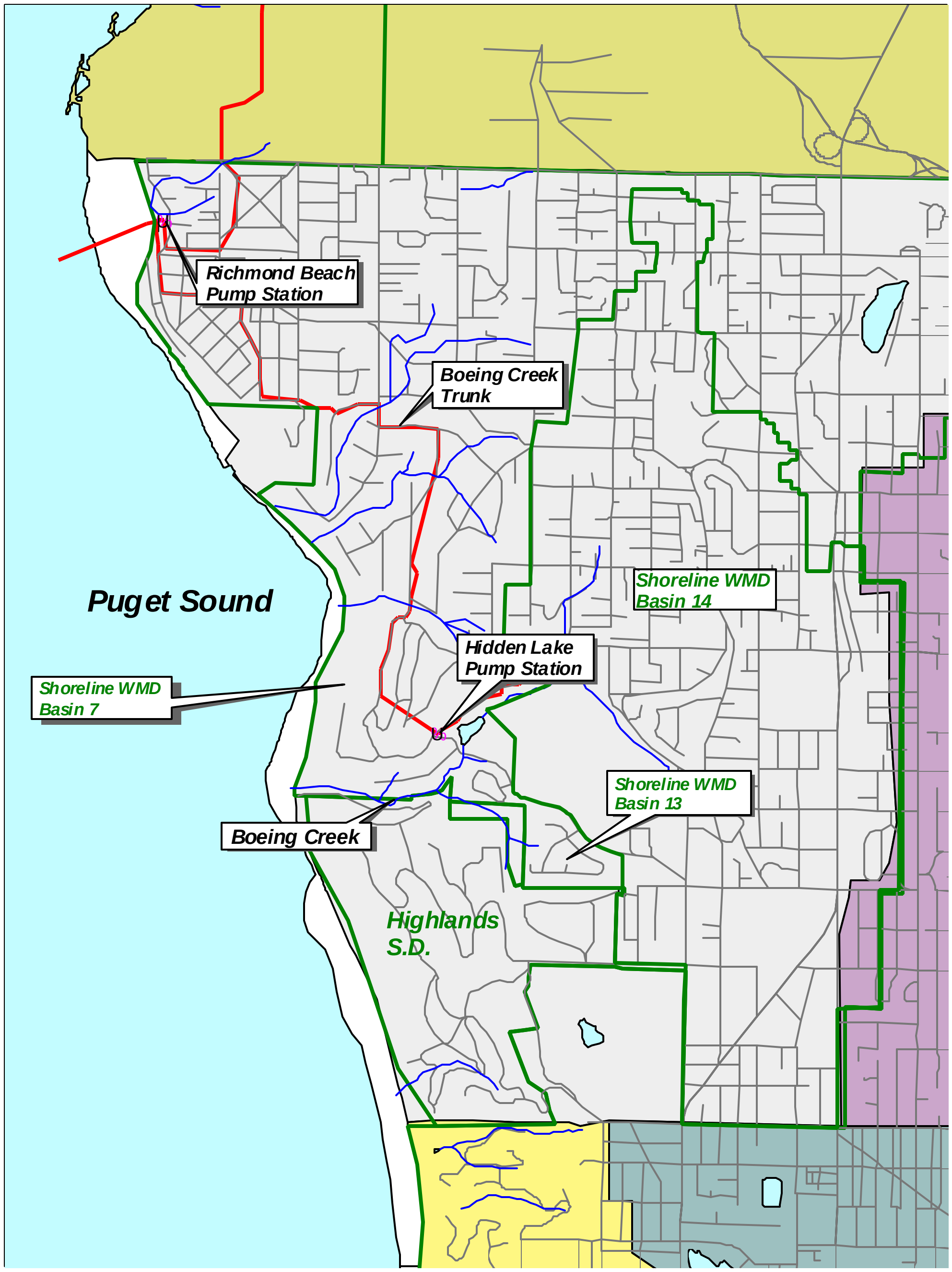

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Figure 2: Hidden Lake Service Area Conveyance System

Legend
- Basin 14
- Pump Stations
- Streams
- Sewer District Boundary
- Road
- King County Conveyance Lines
- Waterbodies

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King County Department of Natural Resources

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N W E S

January 13, 1998

The Hidden Lake Service Area is largely developed and approximately 100 percent sewered with a separated system. Zoning is primarily single family residential, with a concentration of commercial development along Aurora Avenue. The current population is approximately 15,000 and the average annual growth rate has been two to three percent over the past 20 years. Without changes to the current zoning restrictions, the rate of population growth is expected to remain steady. There is potential for multi-family development along Aurora Avenue, and substantial future development would affect population forecasts and sewering needs.

Planning Area Issues and Problems

Several capacity issues have been identified at the Hidden Lake Pump Station and in the downstream conveyance system. The capacity of the pump station and influent line is insufficient for wet weather conditions. Overflows at the pump station occur more than once per year. Utilizing storage along the overflow line and at Shoreline Pump Station No. 4 controls approximately 20 percent of the overflows at the Hidden Lake Pump Station. However the remainder of the overflows result in discharges directly to Puget Sound. A more pressing concern is the downstream conveyance capacity of the system. The pipeline between Hidden Lake and Richmond Beach is storm impacted more frequently than the pump station itself. In addition to backups, corrosion and odor control have been a problem along the pipeline and at the Hidden Lake Pump Station. The following list briefly summarizes specific areas of concern in the Hidden Lake Service Area:

1. The limited capacity of the Boeing Creek Trunk and the Hidden Lake pump station has created backups upstream of the pump station. In response to repeated flooding, a number of residences were disconnected from the Boeing Creek Trunk and connected to a sewer leading to Shoreline Pump Station No.5. Affected King County WTD manholes include B00-39 to B00-42. The January 1, 1997 storm caused a washout at the interconnection of the Shoreline WMD sewers and the Boeing Creek Trunk. While repairing coincident damage from this storm, the Shoreline WMD replaced approximately 185 feet of 15-inch diameter Boeing Creek Trunk pipe with 24-inch diameter concrete pipe.

2. Two Shoreline pump stations (No.4, No. 5) transfer wastewater to the Hidden Lake PS. When both Shoreline pump stations are in operation, the flow volumes are sufficient to stress the Hidden Lake Pump Station capacity, regardless of the quantity of influent from the Boeing Creek Trunk. There has been some concern about the large quantities of infiltration and inflow (I/I) originating in the Highlands SD.

3. Sulfide-related corrosion and odor have been an on-going problem at the Hidden Lake Pump Station and in the downstream piping. The wetwell was relined because of heavy corrosion and temporary odor control equipment is being installed. Corrosion was observed in the downstream piping approximately 10 years ago. At the time, the sections most heavily affected were sliplined. Additional rehabilitation is being performed on previously untreated pipe. The detention times in force main are

generally short. It is suspected that the high rate of corrosion may be due to some high-sulfide sources among the businesses on Aurora Avenue.

4. The process of sliplining has reduced the hydraulic capacity of the system, resulting in an increase in the frequency and severity of storm impacts. Limited downstream conveyance capacity has led to surcharging and/or overflowing manholes and backups into the Shoreline WMD gravity sewers. There are particularly severe storm impacts at the forebay to the siphon located along 14th Avenue NW (manhole BOO-29). Other manholes experiencing hydraulic problems are BOO-22, BOO-8, BOO-4, BOO-3 and BOO-2. The downstream conveyance capacity limitations are so severe that all three pumps in the Hidden Lake Pump Station cannot be operated simultaneously even when overflows are imminent.

PLANNING RECORDS REVIEW

1958 Plan

At the time of the 1958 Plan, the Ronald Sewer District had been formed (in 1951) and financed, with sewer plans in preparation. The original service area was 1.5 sq. mi. A system had also been built at the proposed Boeing Shopping Center (Aurora Avenue and 160th Street) but was not yet operating. The Boeing Shopping Center system had a service area of 0.03 sq. mi. and a capacity of 0.18 mgd. The Highlands private sewer system served a residential neighborhood of 0.7 sq. mi., discharging directly into Puget Sound.

Related Plans by Others

The following list summarizes, in chronological order, the available plans published since 1958:

1. Infiltration/Inflow Analysis for Hidden Lake Pump Station Standby Generator, March 1974.

2. 30th Avenue NE/Hidden Lake Pumping Stations Standby Generators Operation and Maintenance Manuals, December 1979.

3. Final Plan for Secondary Treatment Facilities, Volume II, November 1985.

4. Facilities and Service Area Status Report, January 1987.

5. Richmond Beach Treatment Plant Secondary Treatment Facilities, Predesign Report, May 1987.

6. Richmond Beach Treatment Plant Flow Transfer Project, Facilities Plan Final Predesign Report, April 1988.

7. Richmond Beach Treatment Plant Flow Transfer Project, Amendment to the 1987 Richmond Beach Facilities Plan, Final Predesign Report, July 1988.

8. Offsite Facilities Manual (1985) Revision A, March 1990.

9. Ronald Sewer District Comprehensive Sewer Plan, June 1990.

10. Hidden Lake Pump Station Operations and Maintenance Manual, November 1994.

11. Offsite Facilities and Miscellaneous Structures Manual, Volume 2 West Division, December 1994.

12. Shoreline Wastewater Management District Amendment to the 1990 Comprehensive Sewer Plan, 1995

13. Shoreline Wastewater Management District Infiltration/Inflow Program Phase II Report – Basins 1 and 2, January 1997.

14. Regional Wastewater Services Plan: Executive's Preferred Plan, Draft EIS, Final EIS, Draft Financing Plan, Draft Plan (5 Volumes), April 1998.

15. Preliminary Report on Infiltration/Inflow in the Shoreline Wastewater Management District, Basin 14, expected early 1999.

Differences from Original Service Area

Over the past 40 years, the boundaries and sewering services provided in the Hidden Lake Service Area have expanded. Originally, the only operating sewers were located in the private community known as the Highlands. These flows were discharged directly to Puget Sound without treatment. Today, the entire service area is sewered, and a number local agency and King County owned pump stations help transfer wastewater through the system to the Richmond Beach Pump Station and the Edmonds Treatment Plant.

The following list highlights changes to the service area and facilities since the 1958 Plan:

1962/63 Hidden Lake Pump Station and Sewers: The Hidden Lake Pump Station was completed in July 1962. As-built drawings dated January 1963 show the Boeing Creek Trunk extended from NW 176th St and 6th Ave NW (above pump station) to the Richmond Beach Lift Station (Richmond Beach Drive and 195th Place).

1971 Overflow Line Rerouting: The Hidden Lake Pump Station overflow line was modified to run towards what is now Shoreline Pump Station #4.

1974 Infiltration/Inflow Analysis for Hidden Lake Pump Station Standby Generator: The Hidden Lake Service Area had grown to approximately 2.6 mi2 (1,600 ac). Ronald Sewer District Pump Stations No. 4 and No. 5 had been built. The Highlands neighborhood sewers had been connected to the Ronald Sewer District system, discharging to Pump Station #5. The boundaries stretched from 145th Street to the south and Puget Sound on the west to Aurora Avenue on the east and 203rd Street to the north. The northern and western boundaries were irregularly shaped. The reported population was 7,785. Sizable I/I inputs were observed from the sub-basin located along Aurora Avenue, and from the Highlands Sewer District.

1978 Standby Generator Installed: O&M manual gave Hidden Lake Pump Station drainage area as 2.9 mi^2 (1,850 ac).

1987-1990 Richmond Beach Flow Transfer Project: During the predesign phase of the Richmond Beach Treatment Plant Secondary Treatment Facilities, citizen concerns prompted King County to consider replacing the Richmond Beach TP with a pump station to transfer flows to Edmonds for treatment. The pump station was built at the site of the treatment plant, which was subsequently removed.

1991 Sliplining of Boeing Creek Trunk: Sections of the Boeing Creek Trunk with advanced sulfide-related corrosion were sliplined. See Task 220 – Figure 2 for locations of sliplined pipes. Reduced flow capacity in these sections has been observed.

1990 Ronald Sewer District Comprehensive Sewer Plan: The need for rehabilitation and/or expansion of the existing sewerage facilities was assessed based on population and land use forecasts. It was determined that no additional sewer construction was necessary, however a number of capital improvement projects were suggested. Within the Hidden Lake Service area, these projects include safety improvements to Pump Station No. 5 and the establishment of an Infiltration/Inflow analysis program.

1995 Shoreline Wastewater Management District Amendment to the 1990 Comprehensive Sewer Plan: Updated capital improvement planning information.

REGIONAL WASTEWATER SERVICES PLAN COORDINATION ISSUES

The Hidden Lake Pump Station only handles wastewater generated inside the Hidden Lake Service Area boundary. Currently this wastewater is pumped to the Richmond Beach Pump Station and then transferred to the Edmonds Treatment Plant. The preferred strategy in the current Regional Wastewater Services Plan (RWSP) calls for the construction of a wastewater treatment plant somewhere in northern King County or southern Snohomish County. It is not currently anticipated that potential rerouting in the King County conveyance system will affect the Hidden Lake Pump Station influent. Depending on the siting of the North Treatment Plant and potential changes to King County’s flow exchange program with the city of Edmonds, there could be changes to the conveyance facilities downstream of the Hidden Lake Service Area. Unless the Hidden Lake Pump Station force main is directed away from the Richmond Beach Pump Station, these changes should have no effect on the conveyance capacity and needs of the service area.

GROWTH MANAGEMENT IMPACTS

The Hidden Lake Service Area is primarily comprised of single family residential units. Most properties are zoned RS-7200 or RS-15000 . The service area is approximately 100 percent sewered and is presently experiencing slow growth (less than percent annually). Without changes to the present zoning restrictions, there is little room for further growth for most of the service area. There is some potential some multi-family development along Aurora Avenue. The gravity sewered sub-basins upstream of the Hidden Lake Pump Station have enough excess capacity to handle modest growth. However, any growth within the service area will increase the loadings on the system at the Hidden Lake Pump Station and the Boeing Creek Trunk.

KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT

TASK 220

HIDDEN LAKE SERVICE AREA FACILITIES REVIEW

Hidden Lake Service Area
Task 220: Facilities Review

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INTRODUCTION

The existing wastewater facilities in the Hidden Lake Service Area are described in this memorandum. The King County Wastewater Treatment Division (WTD), Shoreline Wastewater Management District (WMD) and the Highlands Sewer District (SD) own and maintain conveyance facilities in the Hidden Lake Service Area. System inventories and capacities, as well as current rehabilitation requirements and planned conveyance system changes, are discussed for each of the contributing agencies.

The Hidden Lake Service Area conveyance system can be summarized as follows:

- Shoreline WMD and Highlands SD collect and transport sanitary sewage to the King County WTD facilities using a network of gravity sewers, lift stations and force mains.
- King County WTD transports sewage along the Boeing Creek Trunk to the Richmond Beach Pump Station. The Hidden Lake Pump Station, located along the Boeing Creek Trunk, assists with flow transfer to Richmond Beach.
- Downstream of the Richmond Beach Pump Station, wastewater flows to the Edmonds Treatment Plant, in accordance with King County's wastewater treatment sharing agreement with the city of Edmonds.

Hydraulic capacity issues have been identified at the Hidden Lake Pump Station and in the downstream conveyance system. Accordingly, the description of conveyance system facilities has been divided into 2 sections: (1) the Hidden Lake Pump Station and upstream facilities, and (2) facilities downstream of the Hidden Lake Pump Station (see Task 210 memo, Figure 2).

PART I. HIDDEN LAKE PUMP STATION AND UPSTREAM FACILITIES

The Hidden Lake Pump Station receives wastewater flows from three separate sources:

(1) Shoreline WMD Basin 14 located to the east of the pump station,

(2) Shoreline Pump Station No. 4 which serves Shoreline WMD Basin 7, and

(3) Shoreline Pump Station No. 5 which serves the Highlands SD and Shoreline WMD Basin 13.

Each of these areas is described in this section.

Shoreline WMD Basin 14

Shoreline WMD Basin 14 has a total drainage area of approximately 1,300 acres (2 sq. mi.). Shoreline WMD collects and conveys wastewater via gravity sewers to the Boeing Creek Trunk at N.W. 175th Street and 6th Avenue N.W. (MH B00-49). The Boeing Creek Trunk is aligned for approximately one half mile along N.W. 175th Street and 10th Avenue N.W. to the Hidden Lake Pump Station. Table 1 inventories Shoreline WMD pipe diameters for Basin 14.

Table 1. Shoreline WMD Basin 14 sewer system characteristics [a]

Sewer Diameter (in)	Sewer Length (ft)
8	140,450
10	8,745
12	4,960
15	13,035
18	1,715
24	850

a. Source: Infiltration/Inflow Analysis for Hidden Lake Pump Station Standby Generator (Metro, 1974).

At the connection point, three Shoreline WMD sewers (8, 12, 24-inch diameters) discharge to the upstream end of the Boeing Creek Trunk (at manhole B00-49). This was the site of a washout during the January 1, 1997 storm. While repairing the damage caused by this storm, approximately 185 feet of the Boeing Creek Trunk was replaced with 24-inch diameter concrete pipe in an attempt to reduce the potential for backups into MH B00-49. The remainder of the Boeing Creek Trunk above the Hidden Lake Pump Station is 15 or 16-inch diameter.

The only lift station in Basin 14 is a pneumatic ejector (Shoreline P.S. No. 6, see Table 2) located on the south side of 10th Avenue N.W. This lift station serves a small number of houses on the slope between 10th Avenue N.W. and Boeing Creek. Shoreline WMD maintenance practices include complete sewer system cleaning every two years.

Table 2. Shoreline WMD Pump Stations in the upstream conveyance system.

Pump Station	Address	Type	Capacity
P.S. No. 4	16777 16th Avenue N.W.	Wetwell/Drywell	180 gpm @ 93 ft TDH
P.S. No. 5	1057 N.W. 166th Street	Wetwell/Drywell	600 gpm @ 97 ft TDH
P.S. No. 6	17069 10th Avenue N.W.	Pneumatic Ejector	30 gpm @ 34 ft TDH

Shoreline WMD Pump Station No. 4 and Basin 7

Shoreline WMD Basin 7 is a small catchment with a drainage area of 39 acres located in a residential area to the north of the Highlands near Puget Sound. Sewage is collected at Shoreline Pump Station No. 4 (see Table 2) and pumped approximately one third of a mile to the Hidden Lake Pump Station.

Basin 7 is also the site of a marine outfall for the Hidden Lake Pump Station overflows. King County WTD flow monitoring equipment is located at Shoreline WMD MH 139-A (upstream of P.S. No. 4) for estimating overflow volumes. This monitor may be moved to MH 139-C because of upstream diversions at MH 139-A. The details of the overflow line and the Shoreline Pump Station No. 4 discharge are discussed in a subsequent section on the Hidden Lake Pump Station.

Shoreline Pump Station No. 5, The Highlands SD and Shoreline WMD Basin 13

The Highlands is a private community located in the city of Shoreline. The Highlands SD provides sewerage for 103 homes in the community with a total drainage area of approximately 400 acres. The district owns, operates and maintains approximately five miles of separated gravity sewers and force mains ranging in size from 8 to 15 inches in diameter. There are also three small lift stations that assist in transferring flow to the Shoreline WMD Pump Station No. 5 (see Table 2). Firm pump capacities were not readily available, but according to Highlands SD staff, the largest of their pump stations, Lift Station No. 3, has a 3,000 gallon wetwell and after starting up, the pump runs for three to four minutes, before lowering the water level in the wetwell sufficiently to shut off.

The original Highlands sewer system predates the 1958 Metropolitan Seattle Sewerage and Drainage Survey. It was a combined system that discharged directly to Puget Sound. The current separated system was built in the early 1970's, at which time the original sewer system was converted to stormwater conveyance. By ordinance, the Highlands SD has required the removal of roof drain downspouts from the sanitary sewer lines upon any construction, remodeling or landscaping activities. Approximately 40 houses have had downspouts removed in the past six years, leaving only three homes with directly connected downspouts.

Standard Highlands SD maintenance practices involve routine cleaning. Lateral sewers may be cleaned up to four times per year at residents' request. The trunk sewers were CCTV inspected two years ago by Shoreline WMD staff. According to Highlands SD staff, the trunk sewers are in very good condition and contain no cracks.

The Shoreline WMD assesses a usage charge for the wastewater transferred to Pump Station No. 5 from the Highlands SD sewers. Usage charges have been based on pump operating times rather than direct flow measurements. Shoreline WMD also limits the total flow entering Pump Station No. 5 from the Highlands with a weir located upstream of the wetwell inlet. Unfortunately, nobody was able to provide details about the weir or what happens to the wastewater overtopping the weir.

The Highlands SD has been identified as a significant potential source of infiltration and inflow (I/I), primarily due to the long driveways and older lateral sewers within the District. As such, the Shoreline WMD is installing a flow monitor upstream of Pump Station No. 5 to measure wastewater flows from the Highlands SD.

Shoreline WMD Basin 13 is a residential neighborhood of approximately 50 acres located to the southwest of Shoreline Community College and Shorewood Park. Sanitary sewage flows in gravity sewers to Shoreline Pump Station No. 5. These flows are a small portion of total flows at the inlet to Pump Station No. 5.

Hidden Lake Pump Station

The Hidden Lake Pump Station has three raw sewage pumps with a reported combined capacity of 4.2 mgd . Table 3 presents an overview of the pump station equipment characteristics. There are 2 separate influent lines: a 15-inch diameter gravity-fed portion of the Boeing Creek Trunk and a combination 24/10-inch diameter line that carries wastewater from Shoreline WMD Pump Stations No. 4 and No. 5 (Figure 1). When overflows occur, the direction of flow reverses in the 24/10-inch diameter pipe and wastewater travels to Shoreline WMD Manhole 221. In this manhole, there is a weir that admits overflows to an 18-inch diameter line that leads to Shoreline Pump Station No. 4. If overflow conditions do not persist, the overflows may be pumped back to the Hidden Lake Pump Station by Shoreline Pump Station No. 4. Approximately 20 percent of the overflows are controlled in this manner . The remainder is discharged directly to Puget Sound through a 365-foot long section of pipe to a marine outfall. According to Shoreline WMD staff, the capacity of Shoreline Pump Station No. 4 is sufficient for the number of residences in its drainage. Discharges to Puget Sound only occur when the Hidden Lake Pump Station sends overflows to Shoreline Pump Station No. 4.

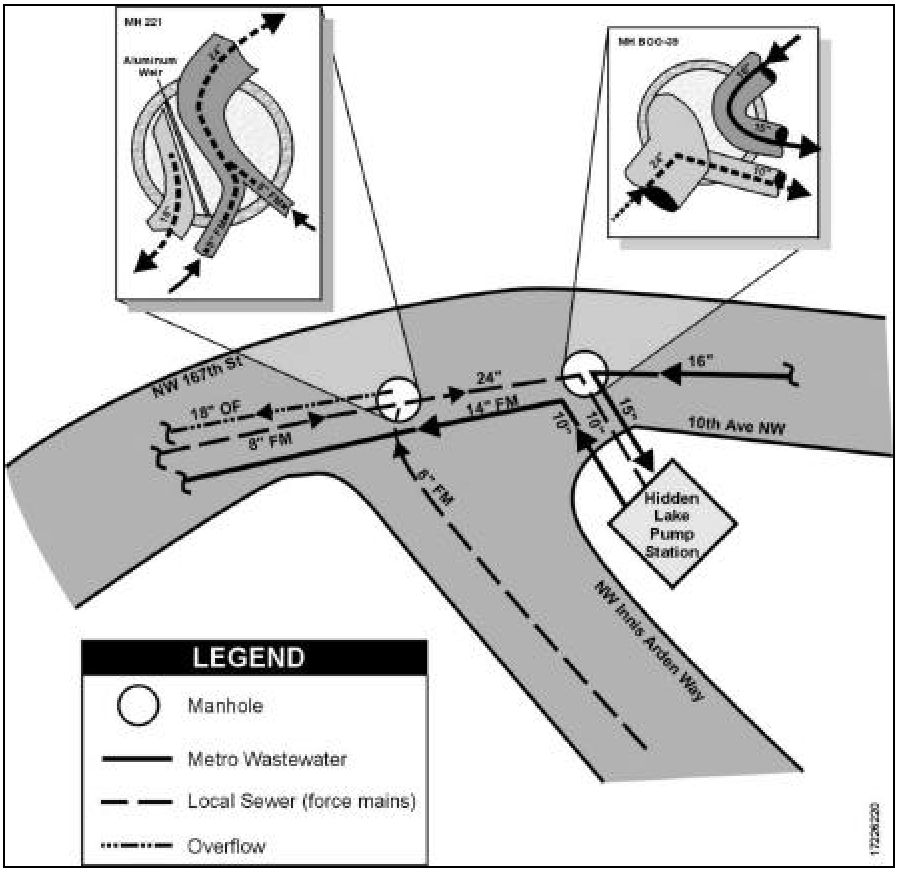

Figure 1. Hidden Lake Pump Station influent and overflow systems

Table 3. Hidden Lake Pump Station characteristics

Date Completed	July 1962
Number of Pumps	3
Pump No. 1 (motor adjustable clutch driven):	Worthington 8FLV16, capacity: 2,100 gpm at 90 ft TDH and 1,145 rpm. Motor: Electricity Machinery C445UP, rating: 75 hp at 1,180 rpm, 3-phase, 440 V, 88.5 A
Pump No. 2 (motor adjustable clutch driven):	same as Pump No. 1
Pump No. 3 (variable frequency drive):	Gorman Rupp T8A3.B Motor: U.S. Motor 354U type H, rating: 40 hp at 1,800 rpm, 3-phase, 440 V, 50 A
Standby Generator	Cummins NT-855-GS, turbocharged, four-cycle, six-cylinder diesel; rating: 355 hp continuous at 1,800 rpm
Wetwell detention time	5 to 10 minutes (ADWF)

PART II. DOWNSTREAM CONVEYANCE SYSTEM

Sources of wastewater in the downstream conveyance system include (1) discharge from the Hidden Lake Pump Station, (2) Shoreline WMD sewers and (3) flows transferred by outside the Shoreline WMD. The drainage area of the downstream conveyance system is approximately 1100 acres (1.7 sq. mi.). The area is approximately 100 percent sewered with a population of approximately 12,000 (customer equivalents).

Hidden Lake Pump Station Discharge and the Boeing Creek Trunk

The Hidden Lake Pump Station discharges to the Boeing Creek Trunk, which then connects to the Richmond Beach Pump Station. Table 4 summarizes flow information for the Richmond Beach Pump Station. The downstream piping is a primarily a combination of force main and gravity sewers, ranging in diameter from 14 to 24 inches. There is also a double-barreled siphon with diameters of 8 and 16-inches with its forebay located at MH B00-29. A King County WTD "no pu" structure is located in the siphon forebay, because of odor problems at this site. Figure 2 shows the locations of the Boeing Creek Trunk and manhole numbers. Table 5 shows pipe lengths and diameters. Downstream of MH B00-38, there are numerous connection points from Shoreline WMD sewers that allow additional wastewater to enter the Boeing Creek Trunk.

Due to extensive corrosion, sections of the Boeing Creek Trunk were sliplined during 1991. The installation of sliplining reduced the hydraulic capacity resulting in an increase in the frequency of storm related impacts. The locations of rehabilitated pipes are also shown in Figure 2. In response to continuing corrosion in previously untreated pipes, rehabilitation is currently planned for additional downstream sections of the Boeing Creek Trunk. In order to minimize the effects of this next rehabilitation on pipe hydraulics, King County WTD may use an in situ impregnated resin technology in lieu of sliplining.

Table 4. Richmond Beach Pump Station flows (mgd)

Flows	1992	2030
Average Annual:	2.1	2.7
Winter Month Average:	3.0	3.8
Winter Month Peak Hour:	7.1	9.2
Summer Month Peak Hour:	2.6	3.4
Summer Minimum Hour:	0.1	0.2

Table 5. Boeing Creek Trunk pipe lengths and diameters

Upstream MH	Length (ft)	Diameter (in)	Upstream MH	Length (ft)	Diameter (in)
B00-49	305	24/15	B00-25	344	18
B00-48	341	15	B00-24	319	15
B00-47	258	15	B00-23	15	18
B00-46	300	15	B00-22A	382	18
B00-45	147	15	B00-22	334	18
B00-44A	145	15	B00-21	407	18
B00-44	246	15	B00-20	132	18
B00-43	286	15	B00-19	59	18
B00-42	123	15	B00-18A	175	18
B00-41	235	15	B00-18	312	24
B00-40	357	16	B00-17A	44	24
B00-39	40 (est.)	16	B00-17	297	18
HL PS	2375	14	B00-16	282	15
B00-38	271	15	B00-15	337	18
B00-37	125	15	B00-14	348	18
B00-36A	48	18	B00-13	333	15
B00-36	334	18	B00-12	252	15
B00-35	439	18	B00-11	427	18
B00-34	126	18	B00-10	288	15
B00-33	141	18	B00-9	206	21
B00-32A	112	18	B00-8	60	15
B00-32	274	18	B00-7	160	15
B00-31	327	18	B00-6	280	15
B00-30	279	15	B00-5	399	15
B00-29	1820	8,16	B00-4	337	21
B00-28	233	18	B00-3	316	24
B00-27	265	18	B00-2	214	24
B00-26	333	15	B00-1		

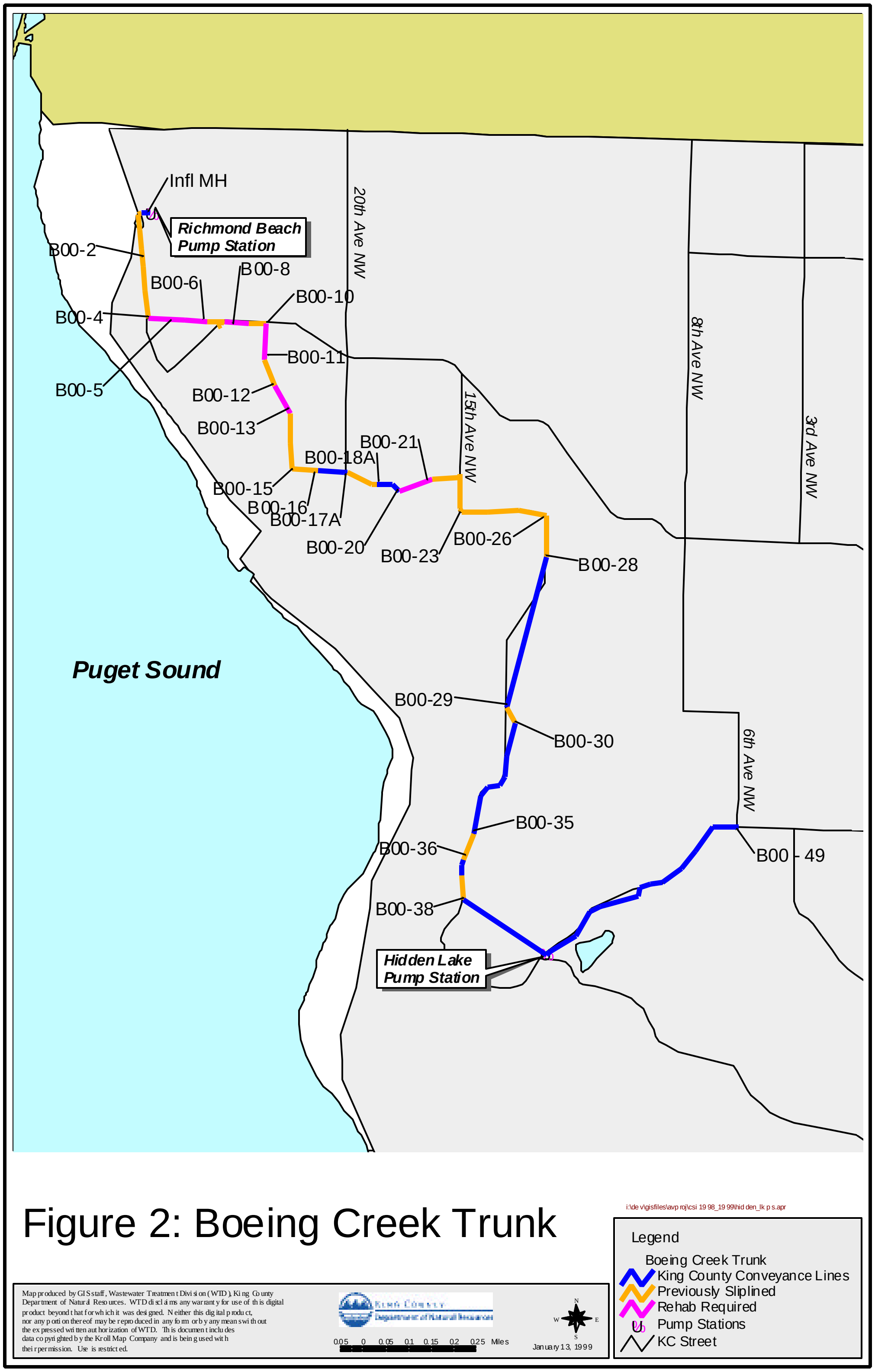

Figure 2: Boeing Creek Trunk

Downstream Conveyance System Shoreline WMD Facilities

There are several Shoreline WMD sewer basins downstream of the Hidden Lake Pump Station that connect to the Boeing Creek Trunk. Shoreline WMD owns, operates and maintains a system of pump stations to assist in transferring flow to the Boeing Creek Trunk (Table 6). The section of the Boeing Creek Trunk is frequently storm impacted. As a result, there have been backups into the Shoreline WMD system. A flap gate was installed at Shoreline WMD MH C5-1A near 15 Avenue N.W. and N.W. 188th Street to prevent backups into a Shoreline WMD customer's home. The flap gate was provided and installed by King County WTD and is maintained by the Shoreline WMD. An I/I analysis was performed for Shoreline WMD Basins 1 and 2, located near the Richmond Beach Pump Station with flow data collected during the 1995 wet season.

Table 6. Shoreline WMD Pump Stations in the downstream conveyance system

Pump Station	Address	Type	Capacity
P.S. No. 1	18316 17th Place N.W.	Wetwell/Drywell	200 gpm @ 120 ft TDH
P.S. No. 2	1628 N.W. 185th Street	Wetwell/Drywell	250 gpm @ 50 ft TDH
P.S. No. 3	17211 15th Avenue N.W.	Pneumatic Ejector	40 gpm @ 35 ft TDH
P.S. No. 11	19101 17th Avenue N.W.	Pneumatic Ejector	50 gpm @ 62 ft TDH
P.S. No. 12	19501 Richmond Beach Drive N.W.	Wetwell/Drywell	400 gpm @ 37 ft TDH
P.S. No. 13	20454 Richmond Beach Drive N.W.	Wetwell/Drywell	450 gpm @ 50 ft TDH

Wastewater from Outside the Shoreline WMD

There are two wastewater sources from outside of the Shoreline WMD that discharge to the Boeing Creek Trunk and Richmond Beach Pump Station: the Chevron Plant at Point Wells and the town of Woodway.

Shoreline Pump Station No. 13 currently only collects wastewater from the Chevron Plant, transfers the flow along Richmond Beach Drive, and discharges to MH B00-4, just upstream of the Richmond Beach Pump Station. Shoreline WMD Pump Station No. 13 is only a few years old, and is presently oversized because of uncertainty in the development plans for its drainage area.

Approximately 156 homes located in south Woodway are serviced by the Shoreline WMD. This neighborhood is topographically separated from the rest of Woodway and would require a pump station if wastewater were not accepted by the Shoreline WMD.

CONTACT LIST:

Information for this section was obtained from the following persons:

Shoreline WMD

General Manager:	Phil Montgomery	(206) 546-2494
Maintenance Manager:	Steve Paulis	(206) 546-2494

Highlands SD

Sewer Commissioner:	Michael Maloney	(206) 364-6764
Maintenance Manager:	Steve Hammond	(206) 362-2100

King County WTD

Facilities Inspection Coordinator	Ed Cox	(206) 684-1292

KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT

TASK 230

HIDDEN LAKE SERVICE AREA CHARACTERIZATION OF EXISTING CONDITIONS

Hidden Lake Service Area
Task 230: Characterization of Existing Conditions

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INTRODUCTION

This memorandum characterizes the physical and natural environment, known sensitive areas, and basin natural resources of the Hidden Lake Service Area (Service Area). In addition, basin land use and growth impacts are identified. This planning and project identification effort includes a description of geological, biological, and other environmentally sensitive conditions in the Service Area that may affect construction of conveyance systems to extend current service capabilities. This information is summarized in Part 1 below. Relevant data from the City of Shoreline and King County was reviewed and summarized in this memorandum. Potential constraints to implementation of the King County Conveyance System Improvement (CSI) project have been identified.

Current and future land use conditions in the Service Area are summarized in Part 2. Land use constraints that may affect the CSI project are discussed.

PART I. NATURAL ENVIRONMENT

Earth/Geological Features

Topography and Soils: Several relatively steep slopes (in excess of 40 percent) are located within the Service Area. Bluffs are located primarily along the Puget Sound shoreline below the Highlands and Innis Arden neighborhoods. The bluffs diminish east of the Richmond Beach area. The remainder of the Service Area is primarily rolling plateau with a north/south topographic orientation. Elevations within the area range from sea level at Puget Sound to a high of just over 500 feet. Boeing Creek is located in a steeply sloped (greater than 40 percent) ravine.

Soils in the Service Area are predominantly Alderwood series soils (City of Shoreline, 1997). Alderwood soils consist of a gravelly, sandy loam, and tend to have sufficient surface drainage. During winter and spring rains, ponding can occur at the soil surface. Erosion can be severe during heavy precipitation events.

Everett series soils appear on the slopes leading down to Puget Sound and in the area of Boeing Creek. The Everett soils are similar to Alderwood soils (gravelly, sandy loam), except they are typically found below 500 feet in elevation. However, because Everett soils are mostly coarse gravel and sand, they tend to drain rapidly.

Erosion Hazards: Erosion hazards are significant within parts of the Service Area, especially along the bluffs of Puget Sound and the steep ravines of Boeing Creek (see Figure 1). The susceptibility of any soil type to erosion depends upon the physical and chemical characteristics of the soil, its vegetative cover, slope length and gradient, intensity of rainfall, and the velocity of water runoff. Significant erosion in the Service Area is most likely to occur along the Boeing Creek ravine and the hillsides in the Richmond Beach area.

Activities associated with clearing, grading, and construction can potentially contribute to erosion and sedimentation potential. Implementation of proper erosion and sedimentation control measures during construction should be used to minimize construction impacts. Following any construction activity, the site should be stabilized and re-vegetated, and drainage systems put in place to further minimize any long-term erosion and sedimentation and sedimentation impacts.

Landslide Hazards: Landslide hazard areas are defined as areas with a combination of greater than 15 percent slopes, impermeable soils, and ground water seepage. Areas with a history of rapid stream incision, stream bank erosion, or undercutting by wave action, as well as areas with a geological history that would indicate landslide susceptibility are also designated as landslide hazard areas. Within the Service Area, these areas include the bluffs along Puget Sound and the Boeing Creek ravine (see Figure 1).

Parts of the Service Area have experienced landslide problems due to water-saturated soils and excessive storm water discharge. In December 1996, a series of heavy snowstorms and rainstorms saturated soils in some parts of the City of Shoreline, causing soil erosion and sloughing. The most significant sloughing of soils occurred in and around Shoreview Park. In the aftermath of this storm, several streets throughout the City suffered severe surface cracking and undercutting beneath the asphalt as soils eroded from the heavy runoff. These events indicate the potential geologic hazards in the area that might occur from soil saturation and storm water runoff. All work in Landslide hazard areas within King County shall comply with the King County Sensitive Areas Ordinance.

Seismic Hazards: Seismic hazard areas are subject to severe risk of earthquake damage because of settlement or soil liquefaction. These conditions occur in areas underlain by soils with low cohesion and density, and are usually associated with a shallow ground water table. When shaken by an earthquake, these soils can lose their ability to support loads. Loss of soil strength can also result in failure of the ground surface and damage to or collapse of structures supported in or on the soil. Loose, water-saturated materials are the most susceptible to ground failure due to earthquakes.

The King County Sensitive Areas Map Folio (King County, 1990) identified one area within the Service Area that has the potential for seismic hazard (see Figure 1). This area is located along the Puget Sound shore in Richmond Beach Saltwater Park. Within this area, structures would be vulnerable to seismic impacts due to ground shaking and ground failure. All work in Seismic hazard areas identified on the King County Sensitive Areas Map Folio shall comply with the King County Sensitive Areas Ordinance.

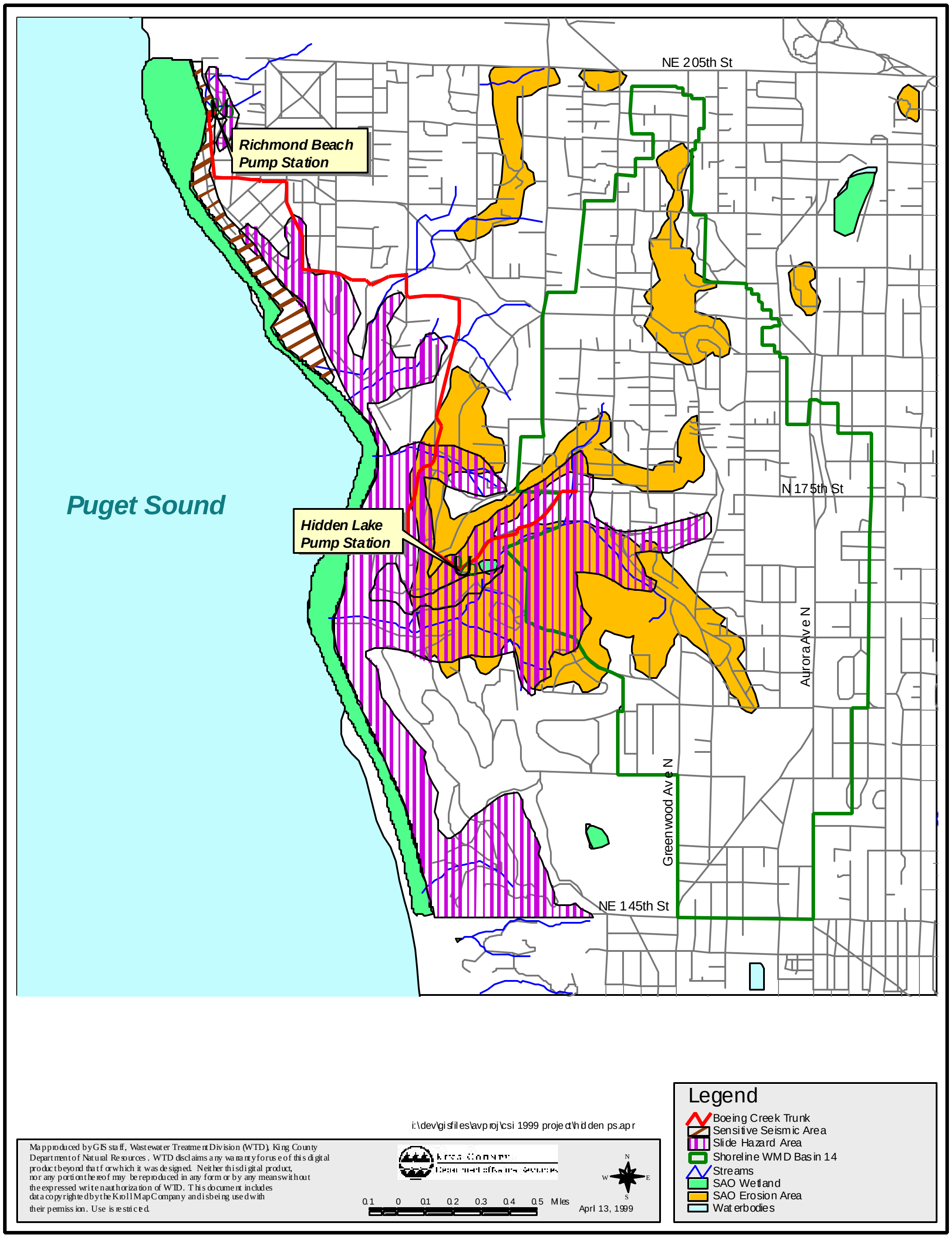

Figure 1. Geological features and environmentally sensitive areas. Sewage collected in Shoreline WMD Basin 14 and areas to the west drain to the Richmond Beach PS.

Hazardous Materials: Based upon documentary information (e.g., King County records) there is no evidence of significant quantities of hazardous materials within the Service Area. Some businesses in the Service Area, such as service stations, manufacturers, paint supply stores, etc., likely use and store hazardous materials. Because the majority of the Service Area is residential, the likelihood of encountering hazardous materials is small, except in those areas identified above.

Significant Vegetation

The City of Shoreline has identified significant areas of primary and secondary types of vegetation within the Service Area. Primary areas are areas of vegetation with little or no development that tend to occur in ravines, steep slopes, native growth easements, natural reserves, and parks. More widespread areas of secondary vegetation cover residential areas and large lots, with interspersed large tree stands. Existing mature vegetation is an important characteristic of the Richmond Beach/Innis Arden area.

Significant areas of vegetation exist at Boeing Creek Park and adjoining Shoreview Park. Boeing Creek Park is listed as a Natural Open Space Area, and Shoreview Park is designated as a Large Urban Park (City of Shoreline, 1998a). Boeing Creek Park is predominantly forested, with the majority of the site being a coniferous forest (City of Shoreline, 1999). The coniferous forest provides habitat for a variety of bird, mammal, amphibian, and reptile species.

Water Features

Surface Water Basins: The Service Area is located within four surface water drainage basins (see Figure 2). These basins include the Boeing Creek Basin, two portions of the Middle Puget Sound Basin (North and South), and a small portion of the West Lake Washington Basins. With the exception of the West Lake Washington Basin, the natural drainage of the majority of the Service Area is to Puget Sound.

The Boeing Creek Basin is the only basin contained entirely within the City of Shoreline, and encompasses approximately 1,575 acres (City of Shoreline, 1997) and its boundaries roughly correspond to those of Shoreline Wastewater Management District (WMD) Basin 14. The basin is approximately 90 percent developed (refer to the land use section below).

The Boeing Creek and two Middle Puget Sound drainage basins are characterized by steep incising channels that have suffered moderate to severe erosion of the channel beds and banks, especially in the lower reaches near Puget Sound. This is typical of areas that were developed prior to the institution of drainage control systems and of areas characterized by steep topography. King County has constructed several drainage detention systems in the Boeing Creek Basin, including a detention pond in Boeing Creek Park near NW 175th Street. Many areas in these basins, particularly along 3rd Avenue NW, flood regularly. The winter storm of 1996 significantly affected these drainage basins. In the Boeing Creek Basin, Hidden Lake filled with sediment and is currently being reconstructed. Hidden Lake sediment removal work was completed in 1997. Road embankments failed at NW 175th Street and 6th Avenue NW, pavement cracked along Carlyle Hall Road, drains were clogged, and the foundations of homes were undermined during this storm.

Streams and Creeks: The streams within the Service Area are illustrated on Figure 2. The King County Sensitive Areas Map Folio (1990) lists all of the streams as unclassified. Unclassified streams are those for which a watercourse has been identified but defining characteristics have not been determined. Further study would have to be done to classify these streams. Boeing Creek is included as an unclassified stream according to the King County Map Folio. In addition, several localized seeps have been identified in the Boeing Creek corridor (City of Shoreline, 1999). These seeps indicate a discharging shallow ground water system in this area.

A fish passage project on Boeing Creek was completed in 1998. All work within the stream or stream buffer shall comply with the King County Sensitive Areas Ordinance. All work within the stream or below the ordinary high water mark shall be authorized by the Washington State Department of Fish and Wildlife through the issuance of a Hydraulic Project Approval.

Shoreline: The King County Map Folio (1990) lists the entire Puget Sound shoreline within the Service Area as Class 1. The Class 1 designation indicates that the waterway is listed and inventoried as a “Shoreline of the State” under the King County Shoreline Master Program, and has a 100-foot buffer requirement. The City of Shoreline Comprehensive Plan (1997) designates the shoreline area into three categories: Urban Shoreline, Rural Shoreline, and Conservancy Shoreline (refer to Figure 2). The purpose of the Urban Shoreline designation is to “ensure optimum utilization of the shorelines of the state within urbanized areas by permitting intensive use and by managing development so that it enhances and maintains the shoreline for a multiplicity of urban uses”. The purpose of the Rural Shoreline designation is to “restrict intensive development, function as a buffer between urban area, and maintain open spaces and opportunities for recreational uses.” Conservancy Shoreline areas are intended to “maintain their existing character.” All work within the “Shoreline of the State” shall require a Shoreline Master Use Permit from the King County Department of Development and Environmental Services. All work within the Shorelines of the State and below the ordinary high water mark shall require a section 404 permit from the Army Corps of Engineers.

Puget Sound is also considered a “shoreline of statewide significance,” as designated by the Shoreline Management Act (RCW 90.58). Alteration of a shoreline of statewide significance can be difficult, and must be consistent with the Shoreline Master Plan. The City’s Puget Sound shoreline has a variety of conditions. In the northern Richmond Beach section, the shoreline has an urban character. Development includes the Point Wells oil tank farm and asphalt plant, Burlington Northern Tracks and rip-rap at the water’s edge, a wastewater pumping station, and dense single-family housing on the waterfront. Community discussions reveal that adequate public access may be lacking, although some community members believe that public access should be restricted to the Richmond Beach Saltwater Park.

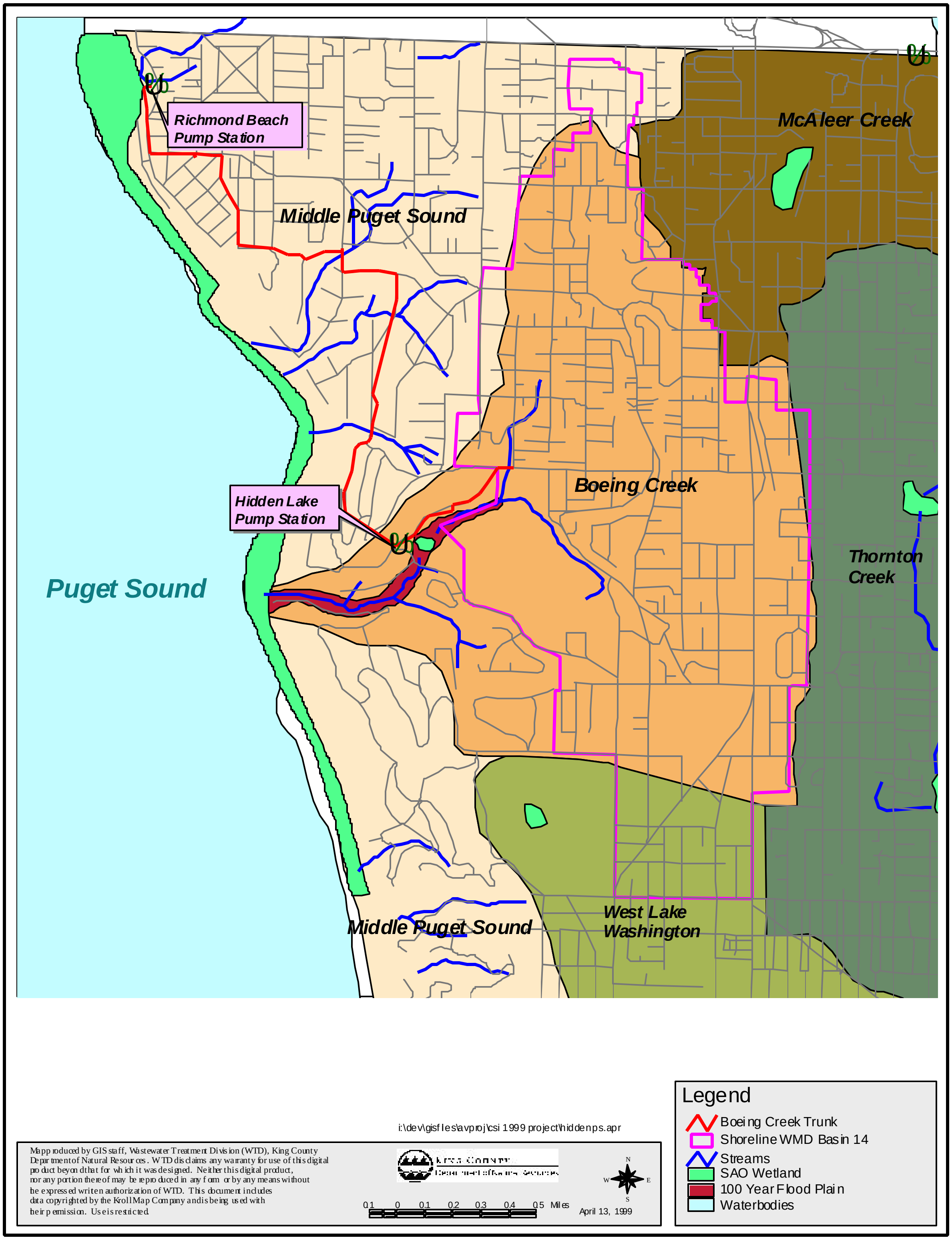

Figure 2. Surface water features of the Service Area.

The middle section of the shoreline has the Burlington Northern tracks and rip-rap at the water's edge, single-family housing upland of the tracks, and Richmond Beach Saltwater Park. The bluff above the railroad tracks begins to rise south of the park.

In the southern half of the shoreline, along the Innis Arden and Highlands neighborhoods, the Burlington Northern tracks and rip rap is at the water's edge without public access. The bluff rises above the tracks, becomes wooded, and is undeveloped.

Flood Hazard Areas: Approximately 37 acres of the Service Area within the Boeing Creek watershed are considered a flood hazard area, corresponding to the 100-year floodplain as delineated and mapped by the Federal Emergency Management Agency (FEMA). The flood hazard area is located along the creek channel from Shoreview Park downstream to Puget Sound (see Figure 2). The 100-year floodplain is an area that has a one percent probability of inundation in any given year. All work within the flood hazard area shall comply with the King County Sensitive Areas Ordinance. Modifications which result in appreciable rise in the 100-year flood elevation will require permission from affected property owners and require a revision to the FEMA flood insurance rate maps.

Wetlands: Wetlands are unique environments comprised of diverse terrestrial and semi-aquatic habitats. Biological habitat support refers to a wetland's provision of nesting, breeding, rearing, and feeding habitat for aquatic and terrestrial wildlife species. Wetland systems within the Service Area offer pockets of habitat for urban wildlife and wetland-dependent plant and animal species. A wetland's size, water quality, diversity of habitat, and habitat structure affect performance and function. All work within wetlands or their buffers are subject to the King County Sensitive Areas Ordinance. Work within wetlands adjacent to Shorelines of the State requires the approval of the Army Corps of Engineers through an Individual Permit.

A review of the background information, including the King County Map Folio and the City of Shoreline Comprehensive Plan, identified two wetlands within the Service Area (see Figure 2). These wetlands are a 253-acre estuarine system (a mixture of salt and fresh waters) adjacent to Puget Sound and a 1.5-acre wetland adjacent to Hidden Lake.

The estuarine wetland along shoreline in the Service Area (refer to Figure 2) is a class 1 wetland with a 100-foot buffer. The low level of urban development along the Puget Sound shoreline indicates that this is the least disturbed and highest quality wetland within the City. This wetland is noted as providing a high degree of storm and flood water storage, providing a high degree of water quality improvement, and having high support for biological habitat. The overall rating of this wetland system is high (City of Shoreline, 1997).

The Hidden Lake wetland, including the lake, is noted as providing moderate storm and flood water storage, moderate water quality improvement, having moderate ground water exchange, and providing moderate biological habitat support. The overall rating for this wetland is moderate.

The identified (documented) wetlands have a minimum size threshold of about one-half acre (i.e., wetlands under one-half acre may exist but were not identified on either the King County Inventory or U.S. Fish and Wildlife Services National Wetland Inventory). Numerous smaller wetlands may exist throughout the Service Area. While individually these areas may be small, their cumulative value to provide wildlife habitat, storm water and floodwater storage and alteration, and groundwater exchange should not be overlooked. These areas may range from regularly mowed, low, wet areas in backyards and parks to relatively undisturbed steep areas along the banks of Boeing Creek and the smaller unclassified streams.

Summary

The potentially most significant natural environment constraints to the CSI project would be construction along the Boeing Creek corridor, along the Puget Sound Shoreline, and the along the bluffs near Richmond Beach/Innis Arden. The Boeing Creek corridor has steep, unstable slopes; seeps; and forested, mature vegetation which may place significant constraints on construction activities. Construction along Puget Sound could involve significant permitting and mitigation for shoreline and estuarine wetland disturbance. Construction through the bluffs represents challenges related to unstable slopes and potentially significant erosion hazards. These challenges will need to be addressed during the study and design of any projects in the area. Alterations to areas with large stands of trees should also be avoided as much as possible.

PART II. LAND USE AND GROWTH IMPACTS

The potential changes in land use practices and their effects on wastewater conveyance needs within the Service Area are described in this section. This assessment is based upon forecasted changes in the population and the distribution of residential, commercial and industrial development in the Service Area, as well as the identified conveyance system facilities and capacity issues (discussed in Task 210 and Task 220 memoranda).

The City of Shoreline recently adopted a comprehensive plan (City of Shoreline, 1998b) to guide social and economic development over the next 20 years. The plan calls for an additional 2,651 residential units to be built in the city through a combination of single-family, multi-family and mixed use development (Table 1). The Hidden Lake Service Area is expected to absorb a substantial portion of the new development.

Table 1. City of Shoreline Comprehensive Plan

	Land Use (acres)		No. of New Units
Residential Single Family:	3,777	(60%)	1,073
Medium Density[a]:	103	(1.6%)	123
Multi-family:	278	(4.3%)	1,228
Mixed Use[b]:	132	(2.1%)	227
Subtotal Residential:	**4,290**	**(68%)**	**2,651**
Commercial:	297	(4.7%)	N/A
Public Facilities:	698	(11.1%)	N/A
Open Space:	658	(10.5%)	N/A
Other	341	(5.7%)	N/A
Total Acres:	**6,284**	**(100%)**	N/A

a. Duplexes and triplexes are examples of medium density housing.

b. Mixed use housing may include a combination of single family, medium density, multi-family and light industrial land use.

The Hidden Lake Service Area is primarily composed of single family residences with minimum lot sizes of 7,200 or 15,000 square feet. There is also a clustering of commercial development along Aurora Avenue and higher density housing on Richmond Beach Drive. The proportion of higher density housing in the Service Area is expected to increase over the next 20 years. The new higher density residential and commercial development will be concentrated along and adjacent to Aurora Avenue, Richmond Beach Drive, and possibly at Point Wells.

Developing vacant lots in established neighborhoods and subdividing private property is how the 1,073 new single family units will be accommodated. Availability and economics will determine the location of these new single family units. It is not known what fraction of the development will occur within the Service Area.

Aurora Avenue: The comprehensive plan calls for redevelopment of the existing Aurora Avenue commercial corridor with the goal of transforming the section between N 175th and N 185th Streets into a city center, distinct from other sections of Aurora Avenue. These redevelopment plans include constructing additional housing, promoting larger floor-area-ratio retail units, and greater accessibility for pedestrians. The new housing will be a combination of medium density, multi-family and mixed use. Multi-family units will not exceed 6 stories in height. This section of Aurora Avenue is part of Shoreline WMD basin 14, which drains by gravity to the Hidden Lake Pump Station.

Richmond Beach Drive: New multi-family residential mixed-use construction would occur in an area that is already zoned for multi-family use. Shoreline WMD sewers along Richmond Beach Drive drain to a previously sliplined gravity section of the Boeing Creek Trunk along Ridgefield Road NW and 15th Avenue NW.

Point Wells: The former Chevron plant at Point Wells (north of the Richmond Beach Pump Station) was identified as a possible annexation site in the comprehensive plan. Potential redevelopment scenarios include the construction of a marina, hotel, parkland and office space while allowing some light-industrial activities to continue. It has also been mentioned as a representative marine site for a future regional wastewater treatment or reclamation plant. Shoreline Pump Station No. 13 is located on the site. It pumps wastewater southward along Richmond Beach Drive to MH B00-4, upstream of the Richmond Beach Pump Station. Shoreline Pump Station No. 13 is only a few years old, and at the time of its construction it was oversized (450 gpm @ 50 ft TDH), to accommodate future development of this area.

Persistent capacity issues at the Hidden Lake Pump Station and in the downstream conveyance system were described in the Task 210 memo. Additional wastewater generation in the Service Area will further strain on the KC WTD sewer system during the wet weather season. In response to the comprehensive plan, the Shoreline WMD is in the process of updating their comprehensive sewer plan and expects to have it completed by September of 1999. According to Shoreline WMD staff, there is sufficient capacity in their collection system to accommodate some increases in wastewater generation.

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KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT

TASK 240

HIDDEN LAKE SERVICE AREA WASTEWATER SERVICE ALTERNATIVE DEVELOPMENT

HIDDEN LAKE SERVICE AREA
TASK 240: WASTEWATER SERVICE ALTERNATIVE DEVELOPMENT

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INTRODUCTION

This memorandum addresses the current conveyance system limitations in the Hidden Lake Service Area (Service Area) and describes three alternatives for conveyance system improvement. The development of these alternatives incorporates projected changes in demand based on population forecasts, infiltration and inflow estimates provided by the King County Wastewater Treatment Division (KC WTD), and information provided in the Hidden Lake Task 210, Task 220 and Task 230 reports.

CONVEYANCE SYSTEM AND HYDRAULIC CAPACITY OVERVIEW

The Hidden Lake Service Area comprises sewer basins that are tributary to the Hidden Lake Pump Station and sewer basins that discharge to King County facilities downstream of the Hidden Lake Pump Station, such as the Boeing Creek Trunk and Richmond Beach Pump Station (Figure 1). This includes approximately 2,495 acres of the Shoreline Wastewater Management District's (WMD) collection system, and the entire Highlands Sewer District (380 acres). The local collection system sewers discharge to the KC WTD conveyance system at the Hidden Lake Pump Station and numerous locations along the Boeing Creek Trunk.

A number of current conveyance capacity, odor control and pipe corrosion problems have been identified at King County facilities in the Service Area. These issues were described in detail in the Task 210 report, and are briefly summarized here.

1. The capacity of the Hidden Lake Pump Station is insufficient to pass wet weather flows. Currently the wet well overflows approximately twice per year during storm events. The stated firm pumping capacity is 4.2 MGD, but the actual capacity is probably closer to 3.8 MGD (Ed Cox, personal communication). This is significantly less than the estimated 20-year peak hour, tributary infiltration and inflow (I/I).

2. The capacity of the Boeing Creek Trunk downstream of the Hidden Lake Pump Station is more limited than the pump station, as evidenced by the higher occurrence of storm impacts. The most frequently affected manholes are B00-29, B00-22, B00-8, B00-4, B00-3 and B00-2, where surcharging and/or overflows have occurred. There has also been extensive sulfide-related corrosion along the pipeline. Previous sliplining work done in response to corrosion has further reduced hydraulic capacity along the Boeing Creek Trunk, increasing the frequency of storm impacts. Figure 2 shows locations of existing sliplined pipe and storm impacted manholes.

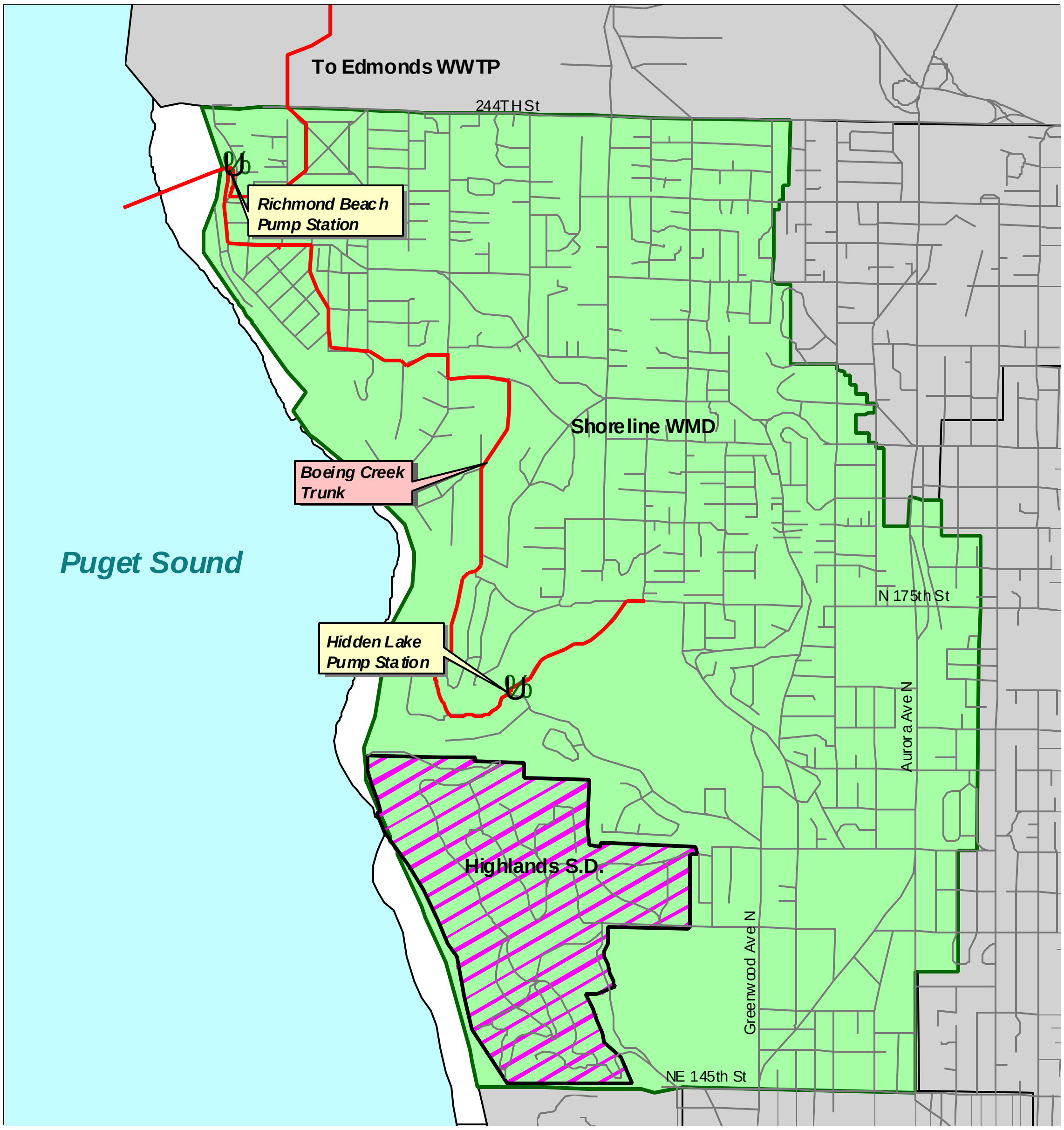

Figure 1: Hidden Lake Service Area Conveyance System

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September 28, 1999

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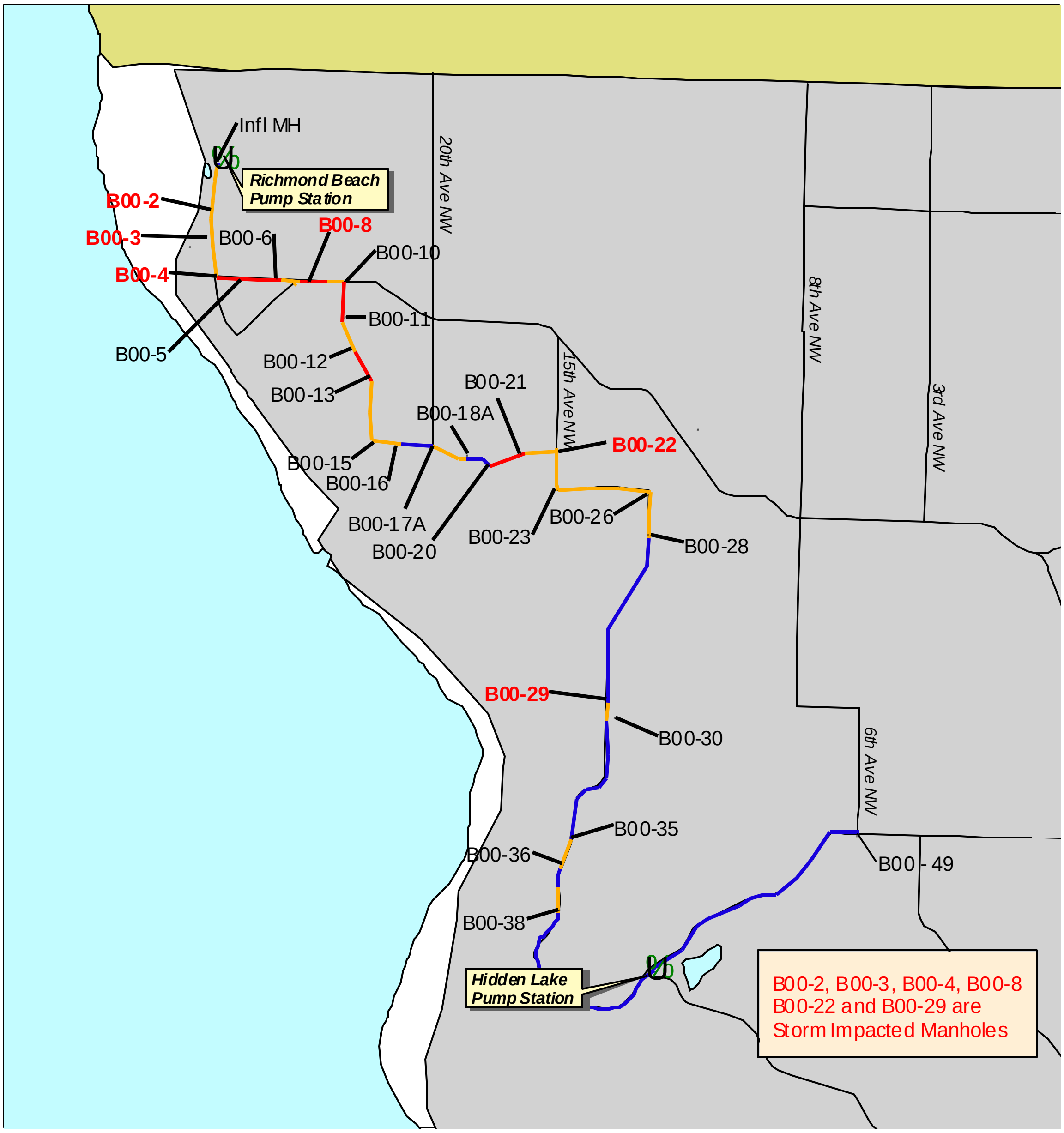

Figure 2: Boeing Creek Trunk

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September 28, 1999

Legend

Boeing Creek Trunk
KC Conveyance Lines
Previously Sliplined
Rehab Required

3. Sulfide-related odor has been an on-going problem at the Hidden Lake Pump Station and Boeing Creek Trunk. Odor control equipment was temporarily installed at the wet well and a “no pu” device has been installed at the siphon forebay at manhole B00-29.

HIDDEN LAKE SERVICE AREA POPULATION PROJECTIONS

To assess the future wastewater conveyance needs within the Service Area, population projections have been obtained from the 1997 City of Shoreline Comprehensive Plan, and the KC WTD. Future population growth within the Service Area will be concentrated in the Shoreline WMD. The Highlands SD serves a private community of approximately 100 homes. The Highlands has a covenant which maintains restrictive zoning rules that make new development unlikely.

Shoreline WMD Population Projections

The City of Shoreline and KC WTD provided the current and future population data used in this study. However, in each case the population forecasts were not reported specifically for the Hidden Lake Service Area, but for larger areas of which the Service Area makes up a portion. For example, KC WTD reported a year 2000[1] population of 26,503 for the 3,988 acre Richmond Beach Basin, of which the Hidden Lake Service Area makes up approximately 2,875 acres[2]. Assuming the Richmond Beach Basin population density is similar both inside and outside the Service Area, a current population of 19,106 is estimated. This is somewhat larger than the 15,000 person estimate given by Shoreline WMD staff (see Task 210 report). This difference will have little impact on conveyance system capacity improvement requirements, since the wastewater base flows are only a small portion (~13% of 20-year peak flow, see Flow Projections below) of the total flow during peak storm events.

Both the KC WTD and City of Shoreline predict slow growth in the Service Area in the coming decades. According to KC WTD estimates, the residential population is expected to increase by 4.9% over the next 30 years (Table 1). The 1997 Shoreline Comprehensive Plan calls for an additional 1,600 to 2,400 residential units[3] (housing for approximately 4,600 people) to be constructed within the city during the 20 year planning window beginning in 1996. This level of anticipated growth is based on an agreement between the City of Shoreline and King County on how to allocate the population growth forecasted by the State Office of Financial Management (OFM) among urbanized communities in King County, in accordance with the Growth Management Act. Shoreline's future land use map shows zoning changes that encourage increased residential and commercial density at the following locations in the Service Area (see Task 230 report):

- Aurora Avenue in Shoreline WMD Basin 14, which is tributary to the Hidden Lake Pump Station.

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[1] These data reflect the June 1999 updates.

[2] The Richmond Beach Basin in the KC GIS *Service Basin* coverage includes some areas that drain to the Lake Ballinger Pump Station and the Olympic View Sewer District. These areas are not part of the Hidden Lake Service Area. The Service Area acreage was provided by KC WTD.

[3] For wastewater generation purposes, a residential unit is defined by King County as 2.4 people in 1996 and 2.2 people in 2010.

- Richmond Beach Road, which has connections to the gravity section of the Boeing Creek Trunk upstream of the Richmond Beach Pump Station.
- Point Wells, which is a potential annexation and development site north of the Richmond Beach Pump Station. Point Wells is served by Shoreline WMD Pump Station 13, which pumps wastewater along Richmond Beach Drive to KC manhole B00-04.

The Service Area covers 45% of the area of Shoreline and includes one third of the population. Based on this information and the zoning changes contained in the Shoreline Comprehensive Plan land use maps, 2,300 people (50% of city-wide growth) is a reasonable estimate of Shoreline's projected growth for the Service Area.

Of the population data examined here, the KC WTD population estimates are higher and therefore provide a more conservative basis for calculating wastewater generation rates. The differences in projected population between the two methods used result in a 0.3 MGD difference is base flow. In determining the required conveyance capacity for KC facilities, however, the differences between the two sets of population estimates are inconsequential, because the majority of peak storm flows are attributable to I/I.

Table 1. Population projections for the Hidden Lake Service Area[a]

King County Wastewater Treatment Division Projections

Year	Residential	Commercial	Industrial
2000	19,106	6,601	89
2010	19,556	6,834	105
2020	19,691	7,335	130
2030	20,036	7,656	149
2040	20,330	8,024	170
2050	20,622	8,391	190

City of Shoreline Projections

Year	Residential	Commercial	Industrial
2000	15,000	N/A	N/A
2020	17,300	N/A	N/A

a. The methods used to determine population are described above.

HIDDEN LAKE SERVICE AREA FLOW PROJECTIONS

KC WTD provided estimates of base flow and I/I flow at the Hidden Lake Pump Station (Table 2). Their projections simulate the effect of conveyance system aging by increasing I/I by seven percent per decade until 2030, the standard used in the Regional Wastewater Services Plan (RWSP).

Table 2. Projected peak flows at the Hidden Lake Pump Station

Year	Base Flow (mgd)	5-year Peak I/I (gpad)	5-year Peak Flow (mgd)	20-year Peak I/I (gpad)	20-year Peak Flow (mgd)
1990	1.23	3,510	7.7	4,400	9.3
2000	1.22	3,770	8.2	4,710	9.9
2010	1.26	4,020	8.7	5,030	10.5
2020	1.28	4,270	9.2	5,350	11.2
2030	1.30	4,530	9.7	5,670	11.8
2050	1.34	4,530	9.7	5,670	11.8

Flow projections were computed along various reaches of the Boeing Creek Trunk by estimating the tributary area to each reach and assuming that both base flow and I/I generation are evenly distributed throughout the Service Area (Table 3). This method had previously been used by KC WTD to estimate flows at specific points in the Service Area. The Hidden Lake Pump Station has a tributary area of 1,831 acres. The tributary area of each reach was estimated from a detailed Shoreline WMD map showing sewer sub-basins. The reaches shown in Table 3 were chosen based on the location of major connections with Shoreline WMD local sewers.

Table 3. Flow projections along the Boeing Creek Trunk for 2050

Reach	Accumulated Tributary Area (ac)	5-Year Peak Flow (mgd)	20-Year Peak Flow (mgd)
B00-49 to HLPS[a]	1,300	6.9	8.4
HLPS to B00-38	1,831	9.7	11.8
B00-38 to B00-29	2,000	10.6	12.9
B00-29 to B00-23	2,100	11.1	13.5
B00-23 to B00-17	2,600	13.8	16.8
B00-17 to B00-04	2,750	14.6	17.7
B00-04 to RBPS[b]	2,875	15.2	18.5

a. Hidden Lake Pump Station

b. Richmond Beach Pump Station

A planning level estimate of the Boeing Creek Trunk conveyance capacity was computed along the reaches given in Table 3 using the Manning's equation for full pipe flow (Manning's friction factor, n=0.013), with pipe lengths and average reach slopes provided by the KC GIS group. Estimates of conveyance system capacity, along with 20-year peak flows for each reach are shown in Table 4 and Figure 3.

Table 4. Boeing Creek Trunk estimated existing conveyance capacities.

Reach	Reach Length (ft)	Average Diameter (in)	Average Slope (%)	Capacity (mgd)	20-Year Peak Flow (mgd)
B00-49 to HLPS	2,803	15.0	2.0	5.9	8.4
HLPS to B00-38	2,375	14.0	FM	3.8[a]	11.8
B00-38 to B00-29	2,476	16.8	1.7	7.4	12.9
B00-29 to B00-23	3,316	15.6	1.4	5.5	13.5
B00-23 to B00-17	2,260	18.0	0.8	6.1	16.8
B00-17 to B00-04	3,718	15.5	4.4	9.6	17.7
B00-04 to RBPS	872	21.3	0.5	7.8	18.5

a. Pump station capacity.

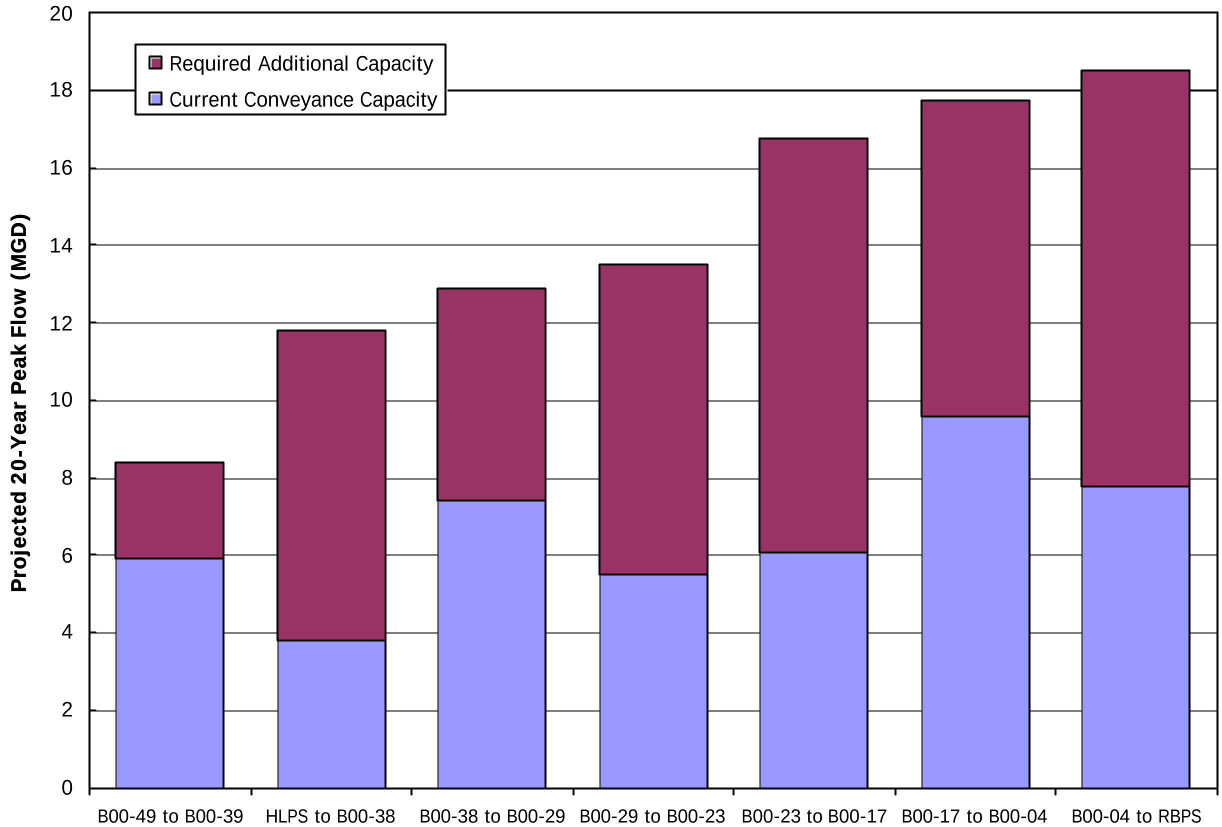

Figure 3. Current and additional required capacity to convey 20-year peak storm along Boeing Creek Trunk.

Figure 3 shows the current conveyance capacity is insufficient to pass the 20-year peak storm. The conveyance system alternatives developed in the next section must provide a method for either increasing the capacity of these facilities or reducing the flows through these facilities to the capacities given in Table 4.

DEVELOPMENT OF CONVEYANCE SYSTEM IMPROVEMENT ALTERNATIVES

This section provides an overview of various approaches to reducing the frequency of conveyance system overflows to once per 20 years[4]. These approaches are organized into three general categories of alternatives:

A. Upgrading the Capacity of Conveyance Facilities and Maintaining Current Wastewater Routing

B. Using Storage to Control Conveyance System Overflows

C. Diverting Peak Wet Weather Flows Away from the Boeing Creek Trunk

[4] King County RWSP standard for separated sewer areas.

Each alternative addresses the replacement, upgrading and/or construction of new KC facilities, construction factors (Appendix A), planning and permitting issues[5], planning level costs and impacts on other KC WTD facilities. We have used 2050 flow projections in designing these alternatives. The Service Area is fully developed and using a 2010 planning horizon would reduce the size of required facilities but would not eliminate the need for additional facilities. The relative costs of the three alternatives would not be significantly affected by shortening the planning horizon.

Impacts of Alternatives on Edmonds Wastewater Treatment Plant

We have met with Edmonds Wastewater Treatment Plant (WWTP) staff to determine whether the plant can accept the additional flows that would result from reducing the frequency of sanitary sewer overflows (SSO) in the Service Area. The Edmonds WWTP has a permitted capacity of 11.8 MGD average monthly flow. The permitted capacity was exceeded in February 1999, when flows averaged 12.4 MGD. During this period, the Edmonds WWTP produced acceptable effluent suspended solids and BOD levels. Plant staff believe the Edmonds WWTP can handle additional flows and are interested in having the WWTP rerated to create a capacity buffer. With a higher rated capacity, the Edmonds WWTP would welcome additional flows from the King County conveyance system.

Alternative A and some sub-alternatives of Alternative C would increase the peak flows at the Edmonds WWTP. The pumping capacity of the plant is 40 MGD and the secondary treatment capacity is approximately 22 MGD. The maximum observed flow at the plant was 28 MGD (for one hour). During the December 1996/January 1997 storm, the plant received a steady influent of 22 MGD for more than 24 hours and still produced 10/10 effluent. Plant staff feel the WWTP can handle the higher peak flows that would result from increasing the hydraulic capacity of the KC system in the Service Area.

Alternative A: Upgrading the Capacity of Conveyance Facilities and Maintaining Current Wastewater Routing

The capacity of the conveyance system would be increased by replacing the Hidden Lake Pump Station with a larger pump station, adding capacity to the Boeing Creek Trunk with a new force main and parallel gravity sewer, and retrofitting/upsizing the Richmond Beach Pump Station (Figure 4). To reduce the potential for sulfide-related odors and corrosion, odor control equipment would be installed at the new Hidden Lake Pump Station and chemical dosing would be provided at the pump station discharge.

[5] Planning and permitting issues, as well as environmental considerations are examined in the Task 250 report.

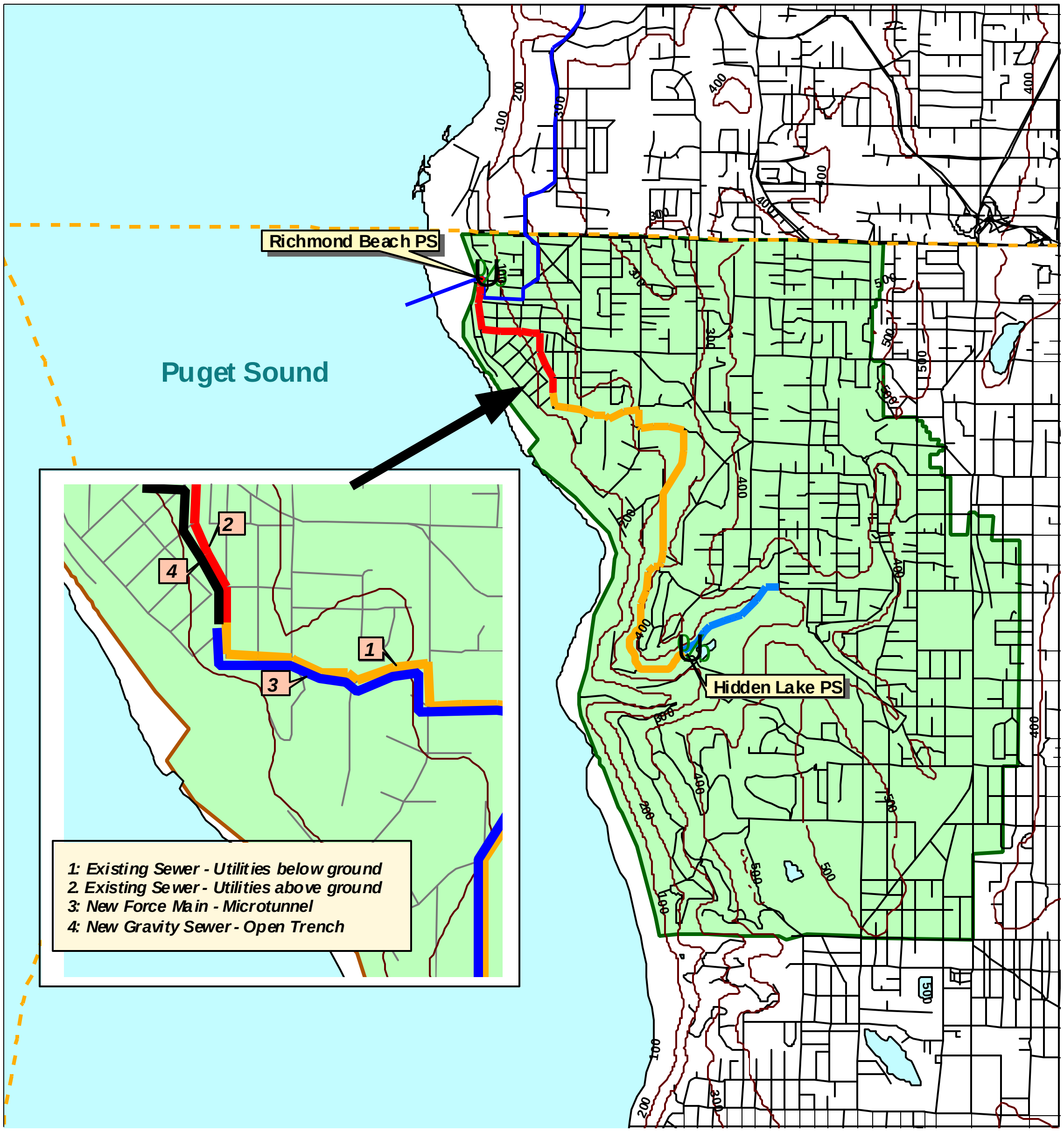

Figure 4: Alternative A

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Upgrading Current Conveyance Facilities

Legend
Boeing Creek Trunk
Add Capacity - Parallel Pipe
Buried Utilities - No Trench
Existing Sewer Unchanged
KC Conveyance Lines
County Boundary
Streets
Hidden Lake Service Area

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September 28, 1999

Pump Station Upgrades

The Hidden Lake Pump Station has been in use since 1963 and would require a tripling of capacity to meet the 20-year peak flow (Table 5). This alternative would replace the existing pump station with a new, larger station, rather than retrofitting the existing station. We have identified a couple of potential sites for the new pump station.

1. The current property could adequate fit a new pump station, if undeveloped land is used. The property has two distinct sections: a relatively flat area that houses the existing pump station and an undeveloped, wooded ravine on the northeast side of the lot. If trees are cleared from the ravine and construction occurs on the slope, there is sufficient room to build an 11.8 MGD pump station.
2. There is a vacant lot at the northwest corner of NW 175th Street and 6th Avenue NW that is large enough for the new pump station. The property is owned by the City of Shoreline. Utilizing this property would require some modifications to the conveyance system. The Shoreline WMD Pump Stations No. 4 and No. 5 force mains discharge near the existing Hidden Lake Pump Station, which is one half mile away and is 70 feet lower than this proposed site for a new Hidden Lake Pump Station. Additional pumps could be used to lift flow to the new pump station, or the Shoreline WMD force mains could intersect the new Hidden Lake Pump Station force main.

The Richmond Beach Pump Station is less than 10 years old, and in good condition according to KC WTD staff. The existing pump station would be retrofitted or expanded to handle an additional 8.1 MGD peak flow. Finding room for expansion should not pose a problem. The Richmond Beach Pump Station sits on a large property with ample space for on-site expansion.

Table 5. Upgraded pump station capacities

	Current Capacity (mgd)	Upgraded Capacity (mgd)
Hidden Lake Pump Station	3.8	11.8
Richmond Beach Pump Station	10.4	18.5

Adding Capacity to the Boeing Creek Trunk

The capacity of the Boeing Creek Trunk would be upgraded to meet flow projections (see Table 4) by constructing a new force main and parallel gravity sewer along the same route as the current trunk. We have examined the available utility maps and discussed previous construction work with KC WTD staff to determine if the existing underground utilities would affect sewer construction along the current route. The Innis Arden neighborhood is an area of concern. A number of buried utilities (storm sewer, water, cable, telephone, electricity, gas) could interfere with trench digging and sewer placement, according to KC WTD staff. For example, KC WTD has had difficulty installing air jumpers along the double-barreled siphon between manholes B00-29 and B00-28. Interference from existing utilities could be avoided by tunneling a force main below existing utility lines.

The force main would extend from the Hidden Lake Pump Station to manhole B00-14. Downstream of B00-14, a gravity sewer could be constructed using conventional techniques, because fewer utilities are located below ground. The new force main/gravity sewer would have an 11.8 MGD capacity and no connections to local agency sewers. The current 3.8 MGD force main (Hidden Lake Pump Station to B00-38) would be abandoned, but the existing downstream gravity section of the Boeing Creek Trunk would remain active and would be used to collect wastewater from Shoreline WMD connections. The initial reaches of the Boeing Creek Trunk (B00-49 to B00-39) would require some modification. If the new pump station is located on the current property, additional capacity will be required upstream of the pump station. If the new pump station is located at NW 175th Street and 6th Avenue NW, flows would be rerouted to the new station. Table 6 shows the proposed configuration of the Boeing Creek Trunk assuming the new pump station is built on the same property as the current station.

Table 6. Boeing Creek Parallel Trunk required pipe diameters

Reach	20-year Peak Flow (mgd)[a]	Conveyance Capacity (mgd)	Length (ft)	Average Slope (%)	Pipe Diameter (in)
Alternative A Proposed Force Main and Gravity Sewer:					
HLPS to B00-14	11.8	11.8	11,343	FM	21[b]
B00-14 to RBPS	11.8	11.8	3,455	4.4	18
Existing Gravity Sewer:					
B00-49 to HLPS[c]	8.4	5.9	2,803	2.0	15
B00-38 to B00-29	1.1	7.4	2,476	1.7	18
B00-29 to B00-23	1.7	5.5	3,316	1.4	18
B00-23 to B00-17	5.0	6.1	2,260	0.8	24
B00-17 to B00-04	5.9	9.6	3,718	4.4	24
B00-04 to RBPS	6.7	7.8	872	0.5	30

a. Downstream of the Hidden Lake Pump Station, peak flows are split between the new and existing sewers. Example: the total flow between B00-29 and B00-23 is 11.8 + 1.7 MGD = 13.5 MGD as reported in Table 4.

b. The force main has been sized to maintain a liquid velocity less than 8 ft/s.

c. Additional hydraulic capacity would be required along the reach.

Tunneling along the current Boeing Creek Trunk route from the Hidden Lake Pump Station to the Richmond Beach Pump Station is a feasible alternative, but there are several undesirable factors that should be considered and mitigated. The new force main will have a net elevation drop of 116 feet. A flow control/energy dissipation device(s) would be required to avoid siphoning at the intermediate high point in the force main, near manhole B00-38.

The turbulent discharge at the end of a long force main would release hydrogen sulfide gas. Odor control equipment would be installed to control off-gassing.

The pump station and trunk expansions discussed in Alternative A would impact the 15,000 foot King County owned Richmond Beach – Edmonds Interceptor and Force Main. While not explicitly considered part of the Hidden Lake Service Area in Tasks 210, Task 220 and Task 230, the Richmond Beach – Edmonds Interceptor and Force Main is included in the development of alternatives. We have estimated the conveyance capacity of this interceptor using Manning's equation for full pipe flow. The 20-year peak flow of 18.5 MGD could be conveyed along several sections of the existing interceptor, while other sections would require additional capacity either through pipe upsizing or parallel piping. Table 7 shows the conveyance capacity of the Richmond Beach – Edmonds Interceptor and Force Main and the size of the parallel pipe that would provide enough capacity to meet the 20-year peak flow. The current force main would need to be upsized or paralleled, and approximately 3,100 feet of gravity sewer would require additional capacity.

Table 7. Flow projections and hydraulic capacity of the Richmond Beach – Edmonds Force Main and Interceptor

Reach	20-year Peak Flow (mgd)	Current Conveyance Capacity (mgd)	Length (ft)	Average Slope (%)	Avg. Pipe Diameter (in)	Required Parallel Pipe Diameter (in)
RBPS to MH 32A	18.5	11.3	5,551	FM	20.0	16[a]
MH 32A to MH 29	18.5	11.1	1,430	0.6	24.0	18
MH 29 to MH 23	18.5	19.1	1,826	2.0	24.7	N/A
MH 23 to MH 19	18.5	11.9	1,709	0.2	30.0	21
MH 19 to MH 1	18.5	29.2	4,835	3.9	25.1	N/A

a. The force main has been sized to maintain a liquid velocity less than 8 ft/s.

Upgrading the conveyance system will increase the peak and volumetric flows arriving at the Edmonds WWTP. Early discussions with treatment plant staff suggest that rerating the plant capacity would be required to accept additional flows. Minimal, if any, hydraulic modifications would be required at the treatment plant.

Alternative B: Using Storage to Control Conveyance System Overflows

Alternative B examines storing peak storm flows as a method of controlling system overflows while limiting the need for upgrading King County facilities. A Storage tank would be associated with either the Hidden Lake Pump Station or the Richmond Beach Pump Station (Figure 5). In performing this analysis, we assume that storage sites are available in the vicinity of the pump station and that all storage will be offline.

The availability of space for siting a storage tank is subject to further study, but our preliminary field visits suggest siting a tank at the Richmond Beach Pump Station would be possible. There is less room for a storage tank at the Hidden Lake Pump Station. Its proximity to a ravine and the level of development in the surrounding residential neighborhood dictate that the storage tank would be located off-site, and would require additional conveyance facilities. The nearest feasible locations are Shoreview Park and Shoreline Community College.

Storage Tank Near the Hidden Lake Pump Station

KC WTD provided estimates of the storage volume necessary to control a 20 year storm for pumping rates of 4, 6 and 8 MGD at the Hidden Lake Pump Station. Using the data provided by KC WTD, Brown and Caldwell computed the required storage volume for a pumping rate of 3.8 MGD, which corresponds to the maximum pumping rate estimate given by Ed Cox of KC WTD.

Table 8. Storage tank volume at Hidden Lake Pump Station for a 20-Year storm

Pumping Rate (mgd)	Storage Volume (MG)
3.8	2.4
4.0	2.2
6.0	1.0
8.0	0.54

Associating a 2.4 MG storage tank with the Hidden Lake Pump Station would allow the maximum pumping rate to remain at 3.8 MGD, and effectively reduce the projected 20-year peak flow downstream of the pump station by 8 MGD. This would have the following impacts on KC facilities in the Service Area:

1. The Hidden Lake Pump Station would not require additional capacity, but odor control equipment would still be required.

2. The Boeing Creek Trunk would still require additional capacity upstream of the Hidden Lake Pump Station and downstream of manhole B00-29.

3. The Richmond Beach Pump Station has a capacity of 10.4 MGD (all pumps) and would probably not require expansion or retrofitting.

4. The Richmond Beach – Edmonds Interceptor and Force Main has a capacity similar to the Richmond Beach Pump Station and would probably not require any additional capacity.

The storm impacts that currently occur downstream of manhole B00-29 are evidence that additional capacity is necessary at the current maximum pumping rate. Table 9 shows the 20-year peak flows along the Boeing Creek Trunk, assuming an offline 2.4 MG storage tank is associated with the Hidden Lake Pump Station. For reaches downstream of the pump station, the flow values are 8 MGD less than the peak flow values reported in Table 4. However, downstream of manhole B00-29, the current trunk capacity is insufficient and either a parallel trunk or a larger, replacement trunk would be required. Approximately 13,000 feet of the Boeing Creek Trunk would require a parallel or replacement pipe. Buried utilities would complicate construction, as described in Alternative A.

Table 9. Boeing Creek capacity with 2.4 MG storage at Hidden Lake Pump Station

Reach	20-year Peak Flow (mgd)	Current Capacity (mgd)	Parallel Trunk Capacity (mgd)	Length (ft)	Average Slope (%)	Pipe Diameter (in)
B00-49 to HLPS	8.5	5.9	2.6	2,803	2.0	15
HLPS to B00-38	3.8	3.8	0.0	2,375	FM	N/A
B00-38 to B00-29	4.9	7.4	0.0	2,476	N/A	N/A
B00-29 to B00-23[a]	5.53	5.48	0.05	3,316	1.4	12
B00-23 to B00-17	8.8	6.1	2.7	2,260	0.8	15
B00-17 to B00-04	9.7	9.6	0.2	3,718	4.4	15
B00-04 to RBPS	10.5	7.8	2.8	872	0.5	15

a. 20-year peak flow and current capacity values are similar. However, there are reported storm impacts along this reach.

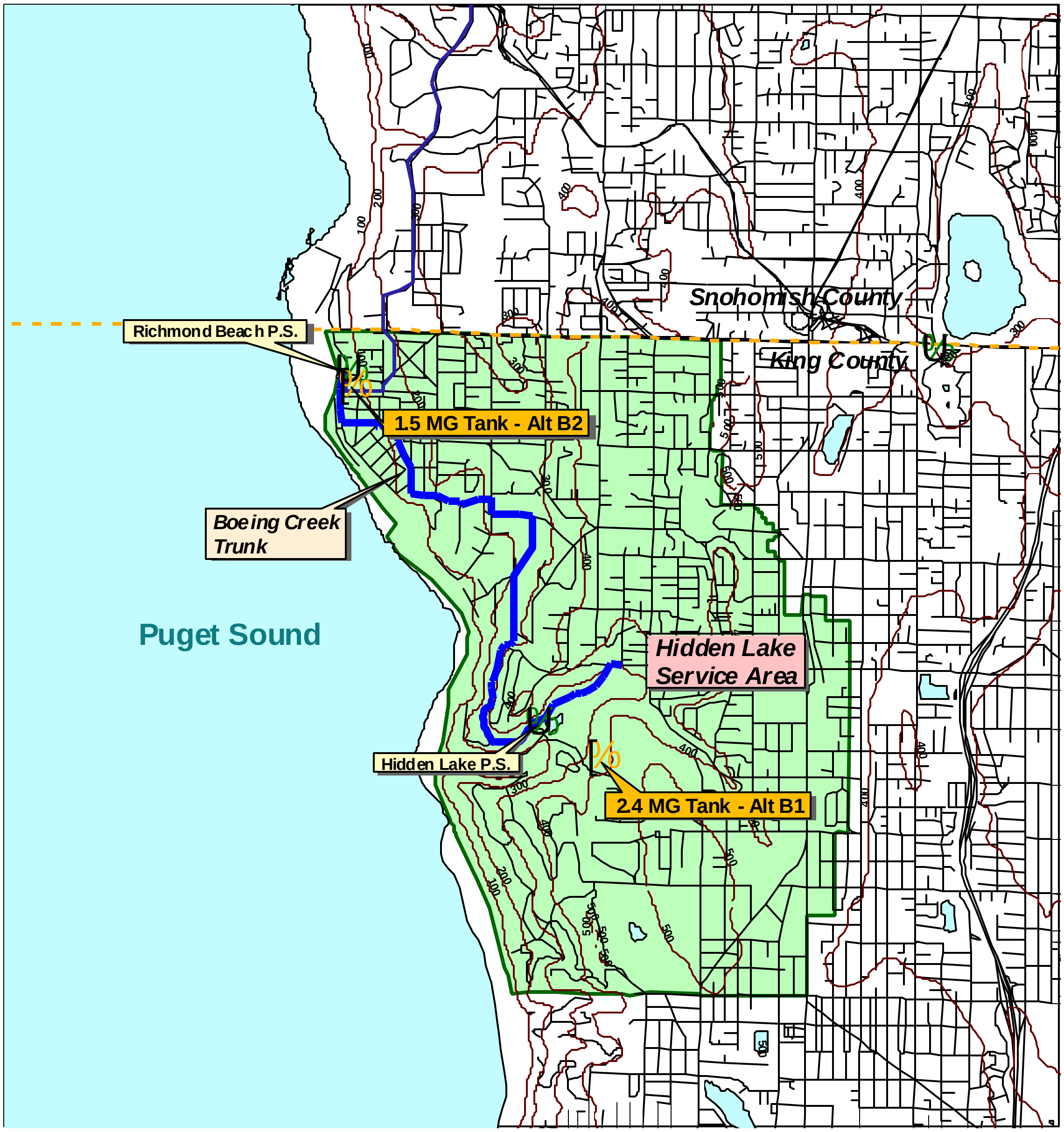

Figure 5: Alternative B

Storing Peak Wet Weather Flows

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0.2 0 0.2 0.4 0.6 Miles

September 28, 1999

Storage Tank at the Richmond Beach Pump Station

KC WTD prepared an estimate of the required storage volume at the Richmond Beach Pump Station to control the 20 year design storm, assuming the upstream conveyance facilities are capable of delivering all flows within the Service Area to the Richmond Beach Pump Station.

Table 10. Storage tank volume at Richmond Beach Pump Station for a 20-Year storm

Pumping Rate (mgd)	Storage Volume (MG)
10.0	1.5

Even though the peak flow at the Richmond Beach Pump Station is substantially higher than at Hidden Lake Pump Station (see Table 3), the estimate of required storage volume at the Richmond Beach Pump Station is lower than at Hidden Lake. This is because a smaller fraction of the design storm hydrograph used to derive these storage volume estimates surpasses the capacity of the Richmond Beach Pump Station than the Hidden Lake Pump Station. Constructing a 1.5 MG storage tank at the Richmond Beach Pump Station would impact the following KC facilities:

1. The Hidden Lake Pump Station would need to be replaced with a larger station, as described in Alternative A.

2. The Boeing Creek Trunk would require a new 11.8 MGD force main and gravity sewer and either flow rerouting or additional capacity between manholes B00-49 and B00-39. See Alternative A for details.

3. The Richmond Beach Pump Station would not require upgrades or retrofits.

4. The Richmond Beach – Edmonds Interceptor and Force Main would not require additional capacity.

The storage tank would be placed under the pump station driveway. During the construction of the Richmond Beach Treatment Plant in the early 1960s, KC WTD staff encountered deep soils under much of the property. The deep soils make it very likely that support piling will be required for any storage tank built on the property. This could potentially increase the cost of storage at Richmond Beach (see Cost Estimates).

Alternative C: Diverting Peak Wet Weather Flows Away from the Boeing Creek Trunk

This alternative would avoid upgrading some existing facilities by routing peak storm flows away from the Hidden Lake Pump Station and Boeing Creek Trunk. The collection point for the conveyance bypass line would be located at the upstream end of the Boeing Creek Trunk (MH B00-49). Manhole B00-49 isolates Shoreline WMD Basin 14, which is the largest

Shoreline WMD sewer basin at 1,300 acres, and has an estimated 20-year peak flow of 8.4 MGD.

A pump station would be constructed on the vacant lot at the corner of NW 175th Street and 6th Avenue NW. This property is currently owned by the City of Shoreline and has an assessed value of approximately $500,000. There are two options for sizing the pump station, 8.4 MGD or 11.8 MGD. An 8.4 MGD pump station could intercept the 20 year peak flow at manhole B00-49. In this case, the Hidden Lake Pump Station could remain at its current size, but downstream reaches of the Boeing Creek Trunk would require additional capacity. In order to maintain the current capacity of the Boeing Creek Trunk, an 11.8 MGD pump station would be constructed on the site, and the Hidden Lake Pump Station effluent would be redirected towards the new pump station. The current Hidden Lake Pump Station force main could be abandoned, similar to Alternative A.

A 2 to 2.5 mile long force main would be constructed along a ridge top, roughly parallel to 8th Avenue NW, that would convey wastewater over the county line into the town of Woodway (Figure 6). The force main would discharge into a one mile long, gravity sewer that would follow the local topography, sloping downward to the west, and connecting to the Richmond Beach – Edmonds Force Main and Interceptor in the vicinity of manhole 32A[6], near 114th Avenue W Park Road and 238th Street SW. Two sections of the Richmond Beach – Edmonds Interceptor, totaling 3,100 feet in length, would be paralleled to increase capacity (similar to Alternative A, see Table 7). A King County constructed and owned sewer is probably the only option for connecting the new force main to the Richmond Beach – Edmonds Interceptor, because the Draft Edmonds Comprehensive Plan indicates the local sewers do not have enough additional capacity.

Table 11. Alternative C facility sizing

	Pumping Rate (mgd)	Force Main Diameter[a] (in)	Force Main Length (ft)	Gravity Sewer Diameter[b] (in)	Gravity Sewer Length (ft)
Alternative C1	8.4	18	10,500	24	5,000
Alternative C2	11.8	21	10,500	27	5,000

Force main sized to keep maximum velocity below 8 ft/s.

Gravity sewer size based on Manning's full-pipe flow equation. The average slope is 0.5%

[6] Manhole 32A is the location of the transition from force main to gravity in the Richmond Beach – Edmonds Force Main and Interceptor.

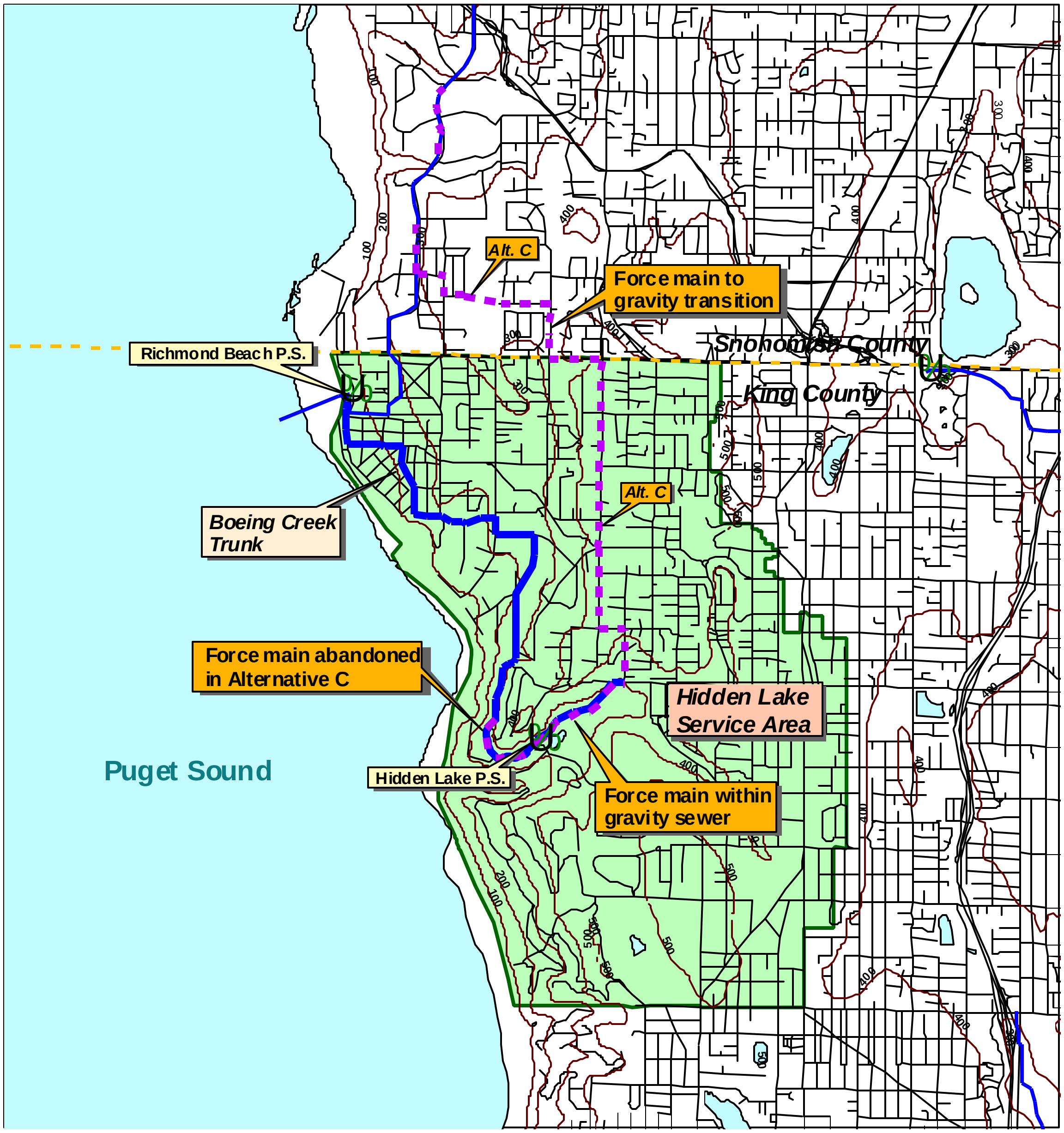

Figure 6: Alternative C

Diverting Peak Wet Weather Flows

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0.2 0 0.2 0.4 0.6 Miles

September 28, 1999

This alternative is similar to Alternative A with the following differences:

- Advantage: One pump station would be constructed/upsized instead of two.
- Advantage: Constructing a new sewer among existing underground utilities would be simpler with the Alternative C route , because there are fewer buried utilities than with the current Boeing Creek Trunk route.
- Disadvantage: Constructing a force main and gravity sewer along a new route would require a greater level of field reconnaissance and as yet unforeseen difficulties.

This option also provides flexibility for future changes to the KC WTD conveyance system in response to the siting of the North Treatment Plant. Wastewater could be directed by gravity from the force main discharge to the Edmonds WWTP, the Richmond Beach Pump Station, and potentially, the Lake Ballinger Pump Station.

Additional Alternatives

The following alternatives were also considered. Initially, these appear less promising than Alternatives A – C, and are only described briefly here (Figure 5).

Alt D1. Pump peak wet weather flows to the northwest to the Lake Ballinger Pump Station.

Alt D2. Transfer flows to the Matthews Park Basin by pumping to the southwest, over the ridge near Aurora Avenue and towards the North Lake City Trunk.

Alt D3. Route a new pressure sewer to either Shoreline Pump Station No. 4 or No. 5, continuing down the bluff, then turning northward adjacent the railroad tracks or along the beach to the Edmonds wastewater Treatment Plant.

Alt D4. Tunnel a new pressure sewer under NW 175th Street to 15th Avenue NW where it would rejoin the Boeing Creek Trunk near manhole B00-33.

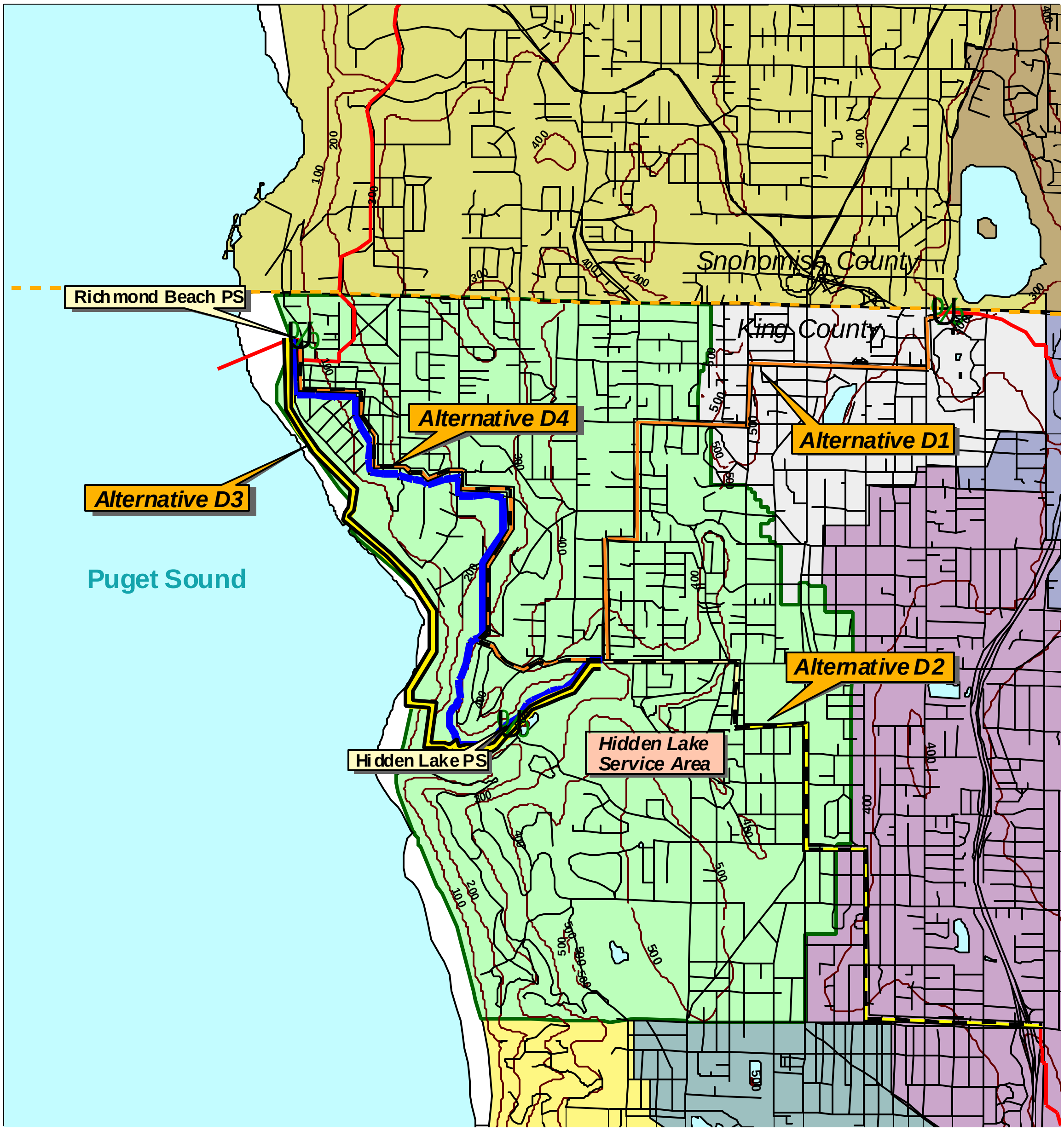

Figure 7: Alternative D

Additional Wastewater Re-Routing Options

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September 28, 1999

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Alternative D1: Route Flows to the Lake Ballinger Pump Station

Wastewater could be routed into the McAleer and Lyon Basin by a new pump station and a three mile long, combination force main/gravity sewer. The new sewer would discharge to the Lake Ballinger Pump Station. After having its capacity increased, the Lake Ballinger Pump Station could pump the wastewater to either the Edmonds WWTP or the McAleer Trunk. The bi-directional pumping capability of the Lake Ballinger Pump Station would provide flexibility to deliver wet weather flows to a North Treatment Plant, once a site is determined. Despite these advantages, there are a couple of substantial drawbacks to this option:

- For conveyance to the Edmonds WWTP, pumping first to the Lake Ballinger Pump Station is an indirect route and requires two pump station, each with more than 150 feet of static lift.

- Pumping to the McAleer Trunk would add flow to the Kenmore Interceptor and downstream sections of the King County conveyance system that are already overloaded in wet weather conditions.

Alternative D2: Route Flows to the Matthews Park Basin

A three and a half mile long force main/gravity sewer could be routed to the southeast to the beginning of the North Lake City Trunk, at the City of Seattle boundary, and into the Matthews Beach Basin. This would help reduce the number of storm impacts in the Service Area and would add no additional flow to the Edmonds WWTP, but it would stress other parts of the King County conveyance system. The North Lake City Trunk would probably require additional capacity to accept the diverted flows. The North Lake City Trunk discharges to the Thornton Creek Interceptor and the Matthews Park Pump Station. The pump station is currently capacity limited.

Alternative D3: Route Flows Along Beach/Railroad Tracks

A new pressure sewer could be constructed to run towards Shoreline Pump Stations No. 4 and No. 5 and then down the bluff near Puget Sound. The pipeline could run northward to run either adjacent to railroad tracks or along the beach to the Edmonds WWTP. The wet weather flows could be conveyed to the Richmond Beach Pump Station entirely by gravity, avoiding most major upgrades to Hidden Lake Pump Station and Boeing Creek Trunk. Despite the potential capital, and operations and maintenance advantages, there are a number of structural and environmental concerns that make this alternative less attractive:

- KC WTD previously ran an overflow line down this bluff, but kept losing the pipe to land movements.

- The railroad tracks at the bottom of the bluff run so close to the hillside that pipe construction would have to occur on the west side of the tracks. The west side of the tracks borders a wetland with potential salmon habitat.

- There would be no appropriate way to flush accumulated solids from the flat part of the pipeline, running near the beach. It is very likely to produce odors on the beach during the summer.

Alternative D4: Route Flows Through a Deep Tunnel Along NW 175th Street

A pressure sewer could be tunneled underneath NW 175th Street from 6th Avenue NW to 15th Avenue NW, before meeting up with the Boeing Creek Trunk near manhole B00-33. This option has the advantage of being more direct than the current Boeing Creek Trunk route, and it would eliminate the need to upsize the Hidden Lake Pump Station. However, it does not help reduce flows along most of the Boeing Creek Trunk, and the tunnel would need to be continued to manhole B00-14 (see Alternative A). Additionally, NW 175th Street is a winding residential street, so the tunnel would have several turns. The maximum depth would be approximately 100 feet, requiring deep jacking/receiving pits.

Cost Estimates for Alternatives

Preliminary cost estimates were prepared for the parallel trunk sewer and pump stations, based on cost curves and information gathered on the Service Area. Our assumptions include 5 percent for mobilization/demobilization, 30 percent for contingencies, 10 percent for legal fees, 20 percent for engineering management and 8.6 percent tax. Extra costs are noted individually for the specific alternatives below. A more detailed cost analysis will be developed as the alternatives are researched further.

Cost Estimates – Alternative A

Table 12 shows planning level project cost estimates for Alternative A.

Table 12. Planning level cost estimates – Alternative A

Facility	Length or Capacity	Cost (million dollars)
Hidden Lake Pump Station	11.8 mgd	5.2
Boeing Creek Trunk	17,800 ft	13.0
Richmond Beach Pump Station	8.1 mgd	6.3
Richmond Beach – Edmonds Force Main and Interceptor	8,700 ft	4.4
Total Project Cost		**28.9**

The Boeing Creek Trunk cost estimate takes into account material costs, excavation pits and tunneling, mobilization/demobilization, traffic control and surface restoration as required, engineering management, tax and contingencies. The Hidden Lake Pump Station cost estimate includes capital costs, mobilization/demobilization, engineering management, tax, contingencies, odor control and chemical dosing equipment. The cost estimate for the Richmond Beach Pump Station expansion is based on the 1991 project cost for pump station construction ($6.25 million). The expansion would increase the pump station capacity by 80 percent, so the original cost has been multiplied by 80 percent and a 4 percent annual inflation rate has been applied. The cost of the Richmond Beach – Edmonds Force Main and Interceptor includes material costs, excavation and trench support, mobilization/demobilization, traffic control and surface restoration, engineering management, tax and contingencies.

Cost Estimates – Alternative B1, Storage at the Hidden Lake Pump Station

Table 13 shows planning level cost estimates for a 2.4 MG, offline storage tank at the Hidden Lake Pump Station and associated conveyance facilities, installation of odor control and chemical dosing equipment at the Hidden Lake Pump Station, and a parallel trunk sewer. Locating a storage tank at Shoreview Park or the Shoreline Community College would require a regulator structure for diversion of flows upstream of the Hidden Lake Pump Station, conveyance to the storage tank, and a pump station and force main from the storage tank to the Boeing Creek Trunk.

Table 13. Planning level cost estimates – storage at Hidden Lake Pump Station

Facility	Length or Capacity	Cost (million dollars)
Hidden Lake Storage Tank	2.4 MG	13.2
Regulator and Connecting Pipeline to Storage Tank	2,500 ft	1.6
8 MGD Pump Station from Storage Tank	8 MGD	4.7
8 MGD Force Main	2,500 ft	2.1
Hidden Lake Odor Control and Chemical Dosing Equipment	N/A	0.5
Boeing Creek Trunk	13,000 ft	9.2
Total Project Cost		**31.3**

A $5.5 per gallon project cost was assumed for the storage tank cost, based on estimating techniques used for the King County RWSP and Combined Sewer Overflow (CSO) projects. This cost assumes that a suitable location for the storage tank is available. The odor control and chemical dosing equipment costs are based on Brown and Caldwell previous experience. The Boeing Creek Trunk parallel line costs are calculated in the same manner as Alternative A.

Cost Estimates – Alternative B2, Storage at the Richmond Beach Pump Station

Table 14 shows planning level cost estimates for a 1.5 MG, offline storage tank (with piling) at the Richmond Beach Pump Station, replacing the existing Hidden Lake Pump Station and constructing a parallel Boeing Creek Trunk.

Table 14. Planning level cost estimates – storage at Richmond Beach Pump Station

Facility	Length or Capacity	Cost (million dollars)
Richmond Beach Storage Tank	1.5 MG	9.1
Hidden Lake Pump Station	11.8 mgd	5.2
Boeing Creek Trunk	17,800 ft	13.0
Total Project Cost		**27.3**

Cost Estimates – Alternative C1, Construction of 8.4 MGD Pump Station near B00-49

Table 15 shows estimated project costs for constructing a 8.4 MGD pump station on the vacant lot near manhole B00-49, acquisition of the property, upgrades to the Boeing Creek Trunk, construction of a new force main and gravity sewer connecting with the Richmond Beach - Edmonds Interceptor and some upgrades to the Interceptor upstream of the Edmonds WWTP.

Table 15. Planning level cost estimates - diverting peak flows with an 8.4 MGD pump station

Facility	Length or Capacity	Cost (million dollars)
Regulator and 8.4 MGD Pump Station	8.4 MGD	5.8
Property Acquisition	N/A	0.5
New 18-inch, 8.4 MGD Force Main	10,500 ft	5.9
New 24-inch, 8.4 MGD Gravity Sewer	5,000 ft	6.2
Upgrades to Boeing Creek Trunk	13,000 ft	9.2
Upgrades to Richmond Beach Int.	3,100 ft	1.6
Total Project Cost		**29.2**

Cost Estimates – Alternative C2, Construction of 11.8 MGD Pump Station near B00-49

Table 16 shows estimated project costs for constructing a 11.8 MGD pump station near manhole B00-49, rerouting Hidden Lake Pump Station effluent to the new pump station, construction of a 11.8 MGD force main and gravity sewer to connect with the Richmond Beach - Edmonds Interceptor and Interceptor upgrades.

Table 16. Planning level cost estimates - diverting peak flows with an 11.8 MGD pump station

Facility	Length or Capacity	Cost (million dollars)
Regulator and 11.8 MGD Pump Station	8.4 MGD	6.4
Property Acquisition	N/A	0.5
Reroute HLPS Flow (3.4 MGD)	3.4 MGD	4.0
New 21-inch, 11.8 MGD Force Main	10,500 ft	6.3
New 27-inch, 11.8 MGD Gravity Sewer	5,000 ft	6.6
Upgrades to Richmond Beach Int.	3,100 ft	1.6
Total Project Cost		**25.4**

Table 17 compares the project costs for the three alternatives examined in Task 240. Alternative C has the lowest costs. These estimates should be considered highly preliminary; a more detailed examination of project costs will be included in Task 250 and Task 310.

Table 17. Summary of project cost estimates for Alternatives A - C

Conveyance System Improvement Alternative	Cost (million dollars)
Alternative A – Increase conveyance capacity	28.9
Alternative B1 – Offline storage at the Hidden Lake Pump Station	31.3
Alternative B2 – Offline storage at the Richmond Beach Pump Station	27.3
Alternative C1 – Diverting Peak Flows Away from Boeing Creek Trunk with 8.4 MGD Pump Station	29.2
Alternative C2 – Diverting Peak Flows Away from Boeing Creek Trunk with 11.8 MGD Pump Station	25.4

APPENDIX A

Steep Slope and Erosion Hazard Area Permitting Considerations within the City of Shoreline

Construction in steep slope (greater than 40 percent) or erosion hazard areas within the City of Shoreline is governed by Title 18 of the city's Zoning Code. The City of Shoreline (Shoreline) requires a sensitive area review for any alteration on a site that includes a sensitive area or is within an identified sensitive area buffer. As part of the sensitive area review, Shoreline will determine whether a sensitive area special study is required.

A sensitive area special study is a written report that identifies and characterizes all sensitive areas in the development area. It should include an assessment of the impacts of any site alteration, and propose adequate mitigation, maintenance, monitoring, or bonding requirements. In the event of steep slope and/or erosion hazard areas, the special study would likely include a geotechnical review and soils evaluation by a geologist or geotechnical engineer.

Per 18.24.310 of the Shoreline Zoning Code, utility corridors may be allowed on steep slopes if a special study shows that alteration will not subject the area to the risk of landslide or erosion.

King County Conveyance System Improvement Project

Task 250

Hidden Lake Service Area Refining Wastewater Service Alternatives

HIDDEN LAKE SERVICE AREA
TASK 250: REFINING WASTEWATER SERVICE ALTERNATIVES

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INTRODUCTION

This report presents refined alternatives carried forward from the Task 240 report and a number of new alternatives for improving wastewater service for King County's Hidden Lake Pump Station/Boeing Creek Trunk system (Figure 1). This report also summarizes a workshop that was held with the consultant team and King County Wastewater Treatment Division (KC WTD) staff to reach agreement on a working alternative to pass to the WTD Capital Improvement Projects section to implement. The report is arranged roughly in chronological order and describes each of the major activities that have been undertaken since the preparation of the Hidden Lake Pump Station/Boeing Creek Trunk Task 240 report. The report contains the following sections:

- Part I: The results of the Task 240 project team meeting. This meeting was held in August 1999 to discuss the alternatives developed in the Task 240 report and to decide which of the alternatives should be given further consideration.

- Part II: The updated flow projections for the Hidden Lake Service Area[1] (Service Area) in the northwest part of King County. After the Task 240 report had been prepared, KC WTD received flow monitoring data collected by the Shoreline Wastewater Management District (WMD) upstream of the Hidden Lake Pump Station. KC WTD incorporated the data to update peak flow projections.

- Part III: The potential for infiltration and inflow (I/I) reduction in the Hidden Lake Service Area and the potential effects of I/I reduction on the sizing of new facilities.

- Part IV: The evaluation of five additional system alternatives that were identified during the December 1999 CSI project team meeting.

- Part V: A synopsis of the March 2000 Task 250 decision workshop, and a description of the working alternative.

This report also includes a number of appendices. Appendix A contains an environmental review of Alternative C (diversion pump station and sewer) and Alternative D3 (waterfront sewer). Appendix B contains the summary memo prepared after the Task 250 decision workshop, and Appendix C contains copies of the decision workshop presentation slides.

[1] The Service Area includes all sewered areas that drain to the KC WTD Hidden Lake Pump Station. Because the operations and potential changes to the Hidden Lake Pump Station affect downstream facilities, the Service Area also includes downstream neighborhoods that drain to the Richmond Beach Pump Station. The extent of the Service Area is shown in Figure 1.

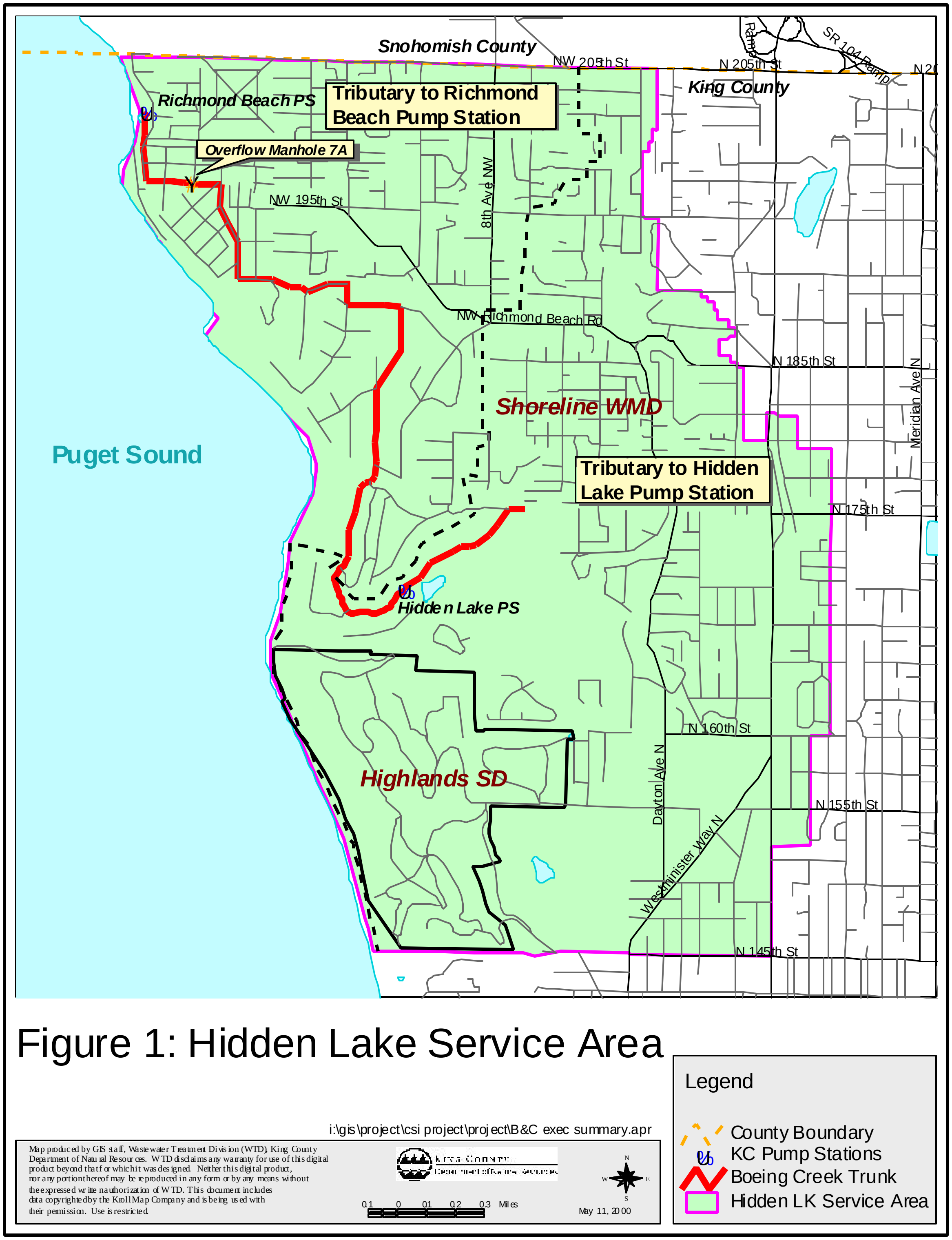

Figure 1: Hidden Lake Service Area

PART I: REVIEW OF TASK 240 PROJECT TEAM MEETING

The CSI project team and KC WTD staff met on August 19, 1999, to discuss which of the alternatives proposed in the Task 240 report were suitable and merited further investigation, and which alternatives should be dropped from further consideration. The Task 240 report contains complete descriptions of the service alternatives that are only briefly discussed herein.

The team meeting participants discussed each alternative in the Task 240 report. All agreed that paralleling the Boeing Creek Trunk (Alternative A) or incorporating tank storage into the system (Alternatives B1 and B2) would not be the best choices. Based on previous experience, County staff were concerned with the difficulties associated with constructing a parallel sewer through the Innis Arden neighborhood due to the number of buried utilities. KC staff also raised operations and maintenance concerns regarding storage. The preliminary cost estimates for Alternatives A and B were also higher than the Alternative C.

The consensus was that Alternative C2 was the most feasible alternative. Alternative C2 would include an 11.8 mgd pump station located near manhole B00-49 to pump wastewater northward towards the Edmonds Wastewater Treatment Plant. A gravity sewer would extend from the force main discharge (near the Snohomish County boundary) to the Richmond Beach – Edmonds Interceptor, intersecting at manhole 32A, for conveyance to the plant.

A set of alternatives that was described but not fully developed was included in Task 240 for completeness. These extra alternatives are collectively referred to as Alternative D. They include diverting flows to the Lake Ballinger Pump Station (Alternative D1), to the North Lake City Trunk (Alternative D2), to a new pressure sewer that would run along the City of Shoreline waterfront to the Richmond Beach Pump Station (Alternative D3), and westward to a new tunnel under to be constructed NW 175th Street (Alternative D4). Alternatives D1, D2, and D4 were not viable solutions. Alternatives D1 and D2 would redirect peak wet weather flows into sections of the KC WTD conveyance system that already have conveyance capacity limitations. The number of turns that would be required for a tunnel and the potential inconvenience to local residents caused by receiving pits were noted shortcomings of Alternative D4.

There are hydraulic advantages of constructing a sewer along the waterfront (Alternative D3). Despite the hydraulic advantages, team members were concerned with the potential environmental impacts of this option and were unsure whether this alternative was truly viable. Concerns included permitting challenges, damage to wetlands, and the stability of the bluff overlooking the proposed pipe alignment.

At the close of the meeting, the CSI project team decided that Alternatives A, B, D1, D2 and D4 would be eliminated from further consideration. Alternatives C (diversion pump station and sewer) and D3 (waterfront sewer) would be carried into Task 250 so that an environmental review of each could be performed. The review found numerous permitting, ESA, and construction problems with Alternative D3, leading the project team to eliminate this alternative from further consideration. See Appendix A for the results of the environmental review.

PART II: UPDATED FLOW PROJECTIONS FOR THE SERVICE AREA

The capacity analysis performed for the Task 240 report was based upon flow projections provided by KC WTD. When the Task 240 report was prepared, there was a lack of available local flow data for the local Service Area basins. KC WTD used observed flows at the Richmond Beach Pump Station along with a more extensive set of flow data from the Lake Ballinger Pump Station. The frequency of overflows upstream of the Richmond Beach Pump Station prevented the gauge at Richmond Beach from recording the full range of flow conditions, making the use of Lake Ballinger Pump Station flow data necessary. After observing the similar rainfall-derived I/I response at the Richmond Beach and Lake Ballinger flow monitors for storms small enough to not produce an overflow, KC WTD was able to assume a hydrologic similarity between the two basins to calibrate its I/I model and generate flow projections.

Differing ages of construction, anecdotal evidence, and previous Shoreline Wastewater Management District (WMD) I/I investigations all suggest that infiltration and inflow enter the collection system in varying quantities throughout the Service Area. Nonetheless, because only one flow monitor within the Service Area was used for the I/I model calibration, a uniform I/I generation rate was assumed for the entire Service Area.

After the preparation of the Task 240 report, KC WTD obtained and analyzed additional flow monitoring data collected by the Shoreline WMD within Basin 14, upstream of the Hidden Lake Pump Station (Table 1, Figure 2). The new flow data show that Basin 14 has higher peak I/I flows that previously assumed. However, the data do not give any indication whether previous I/I estimates for basins downstream of the Hidden Lake Pump Station were accurate or complete.

Table 1. Sub-Basin flow - tributary to Hidden Lake Pump Station[a]

Basin	Area (ac)	Base Flow (mgd)	5-yr I/I (gpad)	5-yr Peak Flow (mgd)	20-yr I/I (gpad)	20-yr Peak Flow (mgd)
J25[b]	200	0.10	5,340	1.17	7,780	1.66
J7 (lower)[b]	150	0.08	2,600	0.47	4,300	0.65
J7+J25[b]	350	0.18	4,100	1.61	6,290	2.38
D4[b]	350	0.35	6,810	2.72	9,240	3.56
Unmonitored Basin 14[c]	600	0.30	4,100	2.76	6,290	4.07
Basin 7 (unmonitored)[d]	50	0.01	N/A	0.26	N/A	0.26
HSD & Basin 13 (unmonitored)[d]	400	0.04	N/A	0.86	N/A	0.86
Totals:	**1,750**	**1.06**		**8.2**		**11.1**

a. Flow projections are based on values provided by KC WTD. The estimated sewered area is lower than in the Task 240 report, because some unsewered areas within Basin 14 (e.g. parks) were removed.

b. These sub-basins are contained in Shoreline WMD Basin 14 and have been flow monitored.

c. I/I flows for unmonitored areas are set equal to the J7+J25 I/I rates. The land use patterns for the unmonitored basins are more similar to those of sub-basins J7+J25 than sub-basin D4.

d. Peak flows are set equal to the capacity of Shoreline lift stations 4 and 5.

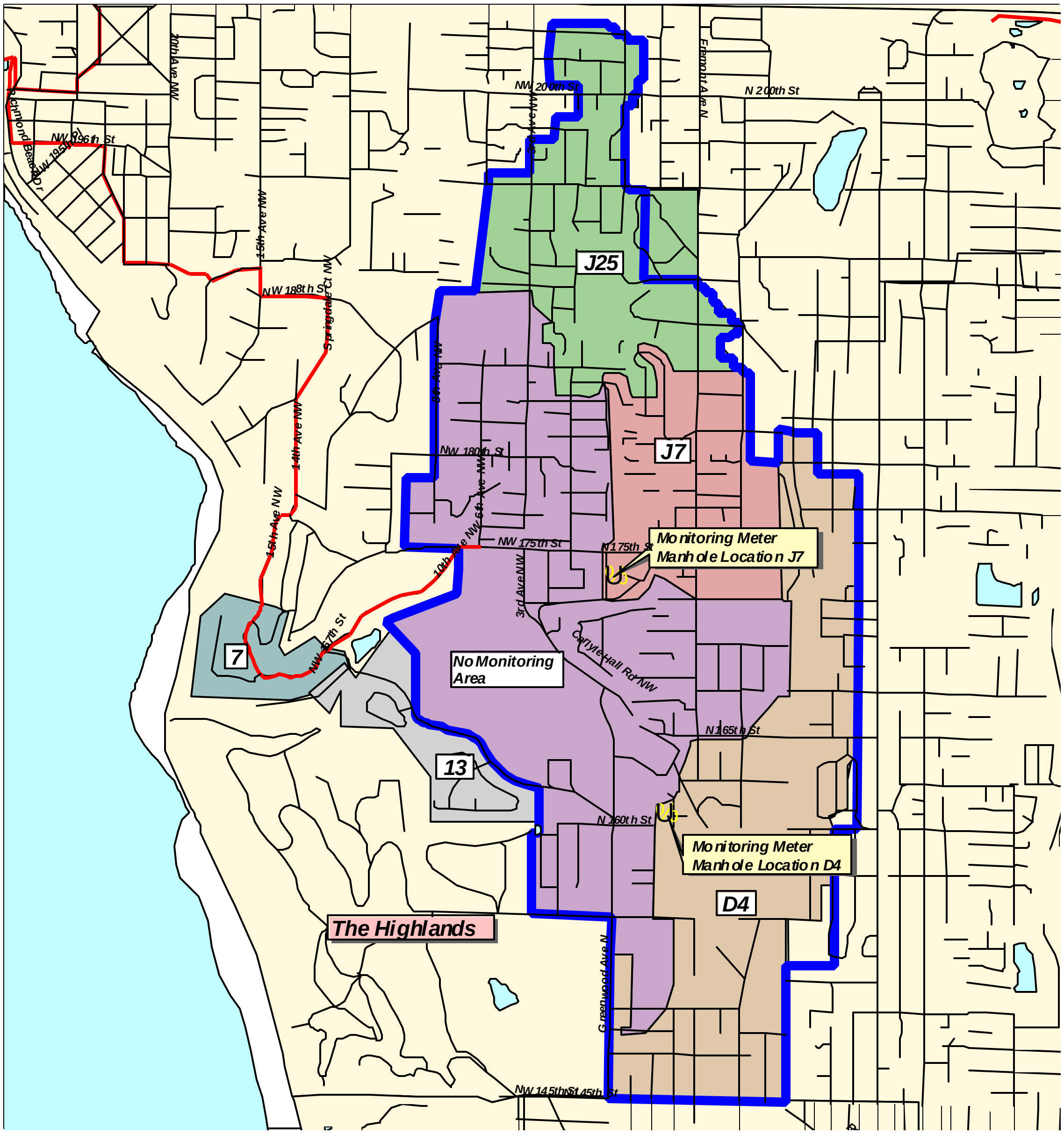

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Figure 2

Hidden Lake PS Portable Monitors

Map produced by GIS staff, Wastewater Treatment Division (WTD), King County Department of Natural Resources. WTD disclaims any warranty for use of this digital product beyond that for which it was designed. Neither this digital product, nor any portion thereof may be reproduced in any form or by any means without the expressed written authorization of WTD. This document includes data copyrighted by the Kroll Map Company and is being used with their permission. Use is restricted.

0.1 0 0.1 0.2 0.3 Miles

April 17, 2000

N W E S

Legend

- Roads
- KC Conveyance Line
- Shoreline WMD Basin 14 Boundary
- Service Basins

The monitored sections of Basin 14 have higher peak I/I rates than the Service Area average of 4,710 gpad for the 20-year peak (see Task 240 report, Table 2, year 2000 flow estimates). Because not all sections of Basin 14 were isolated by flow monitoring, some basins were assigned I/I rates based on neighboring sub-basins with similar land use patterns. Table 2 gives a new estimate of the 20-year peak flow at the Hidden Lake Pump Station by summing the peak flows from the individual sub-basins.

Shoreline WMD Basins 1 and 2, located near the Richmond Beach Pump Station, are also high I/I areas. The sewers in these basins are among the oldest in the Service Area and published Shoreline WMD data show a strong hydrograph response to rainfall. The time-series flow data were not available for this study, so the 20-year peak flow for these basins has not been estimated.

Table 2. Comparing peak flows at the Hidden Lake Pump Station

Source	5-Year Peak Flow (mgd)		20-Year Peak Flow (mgd)	
	Year 2000	Year 2050	Year 2000	Year 2050
Task 240 Flows [a]	8.2	9.7	9.9	11.8
Updated Flows	8.2 [b]	9.7 [c]	11.1 [b]	13.2 [c]

a. Data from Task 240 report, Table 1.

b. Flows are summed from Task 250 report, Table 1.

c. Task 250 flow projections for 2050 assume base flow and I/I increase at the rate established in Task 240.

These updated flow projections would not change the conclusions reached by participants at the Task 240 meeting, regarding Alternatives A and B. The basic layout of these two alternatives would not change, but larger facilities than those proposed in Task 240 would be necessary. Construction of larger facilities would increase costs, and the construction difficulties, and operations and maintenance issues discussed in the Task 240 project team meeting would still be a concern. Alternatives A and B are still considered less feasible than Alternative C and not subject to further analysis.

Alternative C would divert wastewater upstream of the Hidden Lake Pump Station under peak wet weather conditions to a new pump station and force main to limit flows through existing facilities and reduce the number of overflows at the Hidden Lake Pump Station and manhole 7A. The diversion pump station would be run intermittently throughout the wet season; KC WTD staff would develop the procedure by which the station would operate. Alternative C would also route wastewater generated downstream of the Hidden Lake Pump Station through existing facilities with no capacity upgrades.

Accurate flow projections upstream of Hidden Lake are necessary for sizing the new facilities. Accurate flow projections downstream of Hidden Lake are also necessary to verify the adequacy of existing facilities, under both low flow and high flow conditions. To summarize, prior to final design, the following assumptions should be verified by collecting additional flow monitoring data:

1. After diverting all wastewater upstream of the Hidden Lake Pump Station, there would be sufficient capacity in the Boeing Creek Trunk to convey the remainder of the 20-year peak flow.

2. Under low flow conditions, there would be adequate flow to limit deposition of solids along the Boeing Creek Trunk. Particular attention should be given to the hydraulics of the inverted siphon (forebay at manhole B00-29). KC operations staff indicated the Hidden Lake Pump Station will need to be replaced with an updated pump station, regardless of capacity issues. Designing the new Hidden Lake Pump Station with bidirectional pumping ability should meet low flow requirements in the Boeing Creek Trunk (e.g. the Hidden Lake Pump Station would discharge to the diversion pump station during peak storm events and to the Boeing Creek Trunk during dry weather).

3. The proposed new pump station located near manhole B00-49 should have a pumping capacity sufficient to pass the 20-year peak flow. Previous estimates placed the 20-year peak flow at 11.8 mgd. KC WTD's analysis of additional flow data suggests the 20 year peak flow would reach 13.2 mgd at the end of the planning window. This value must be verified or adjusted based on the results of additional Basin 14 flow monitoring conducted by KC WTD during the regional I/I program.

Refined Population Forecasts for the Service Area

This section contains refined KC WTD population forecasts for (1) the Service Area and (2) the area upstream of the Hidden Lake Pump Station. This section also includes comparisons of population forecasts developed for the *1999 Shoreline Comprehensive Plan* and the upcoming *Shoreline WMD Comprehensive Sewer Plan* (currently in draft form).

Population forecasts are important for projecting sanitary base flows. KC WTD assumes usage at 60 gpcd (gallons per capita per day) for residential, 35 gpcd for commercial and 75 gpcd for industrial users. Shoreline WMD uses 85 gpcd for residential users to cover all sanitary base flow. While the previous section (*Part II: Updated Flow Projections for the Service Area*) demonstrated that sanitary base flow comprises a small fraction of the 20-year peak flow and has little effect on facility sizing, sanitary base flow is important for defining low flows, which help determine the range of facility operations.

<u>Refined KC WTD Population Forecasts</u>

The population forecasts (residential, commercial, industrial) prepared in Task 240 were refined for the Task 250 report. In Task 240, KC WTD forecasts were based on the Puget Sound Regional Council's (PSRC) estimates for the Richmond Beach wastewater service basin, of which the Service Area comprises approximately 75 percent[2]. The Service Area forecasts were developed by multiplying the Richmond Beach wastewater service basin population data by this fraction, 75 percent. This method assumes that the distribution of population in the Richmond Beach wastewater service basin is representative of the Service Area.

In Task 250, the Service Area population forecasts were refined by using GIS analysis techniques to sum the population forecasts for the individual Traffic Analysis Zones (TAZ) that are contained in the Service Area[3]. The TAZ population data were provided by the PSRC[4]. The data source is the same as Task 240, but the analysis here is more detailed. These refined forecasts show that continued slow growth is expected throughout the 50-year planning window (Figure 3, Table 4).

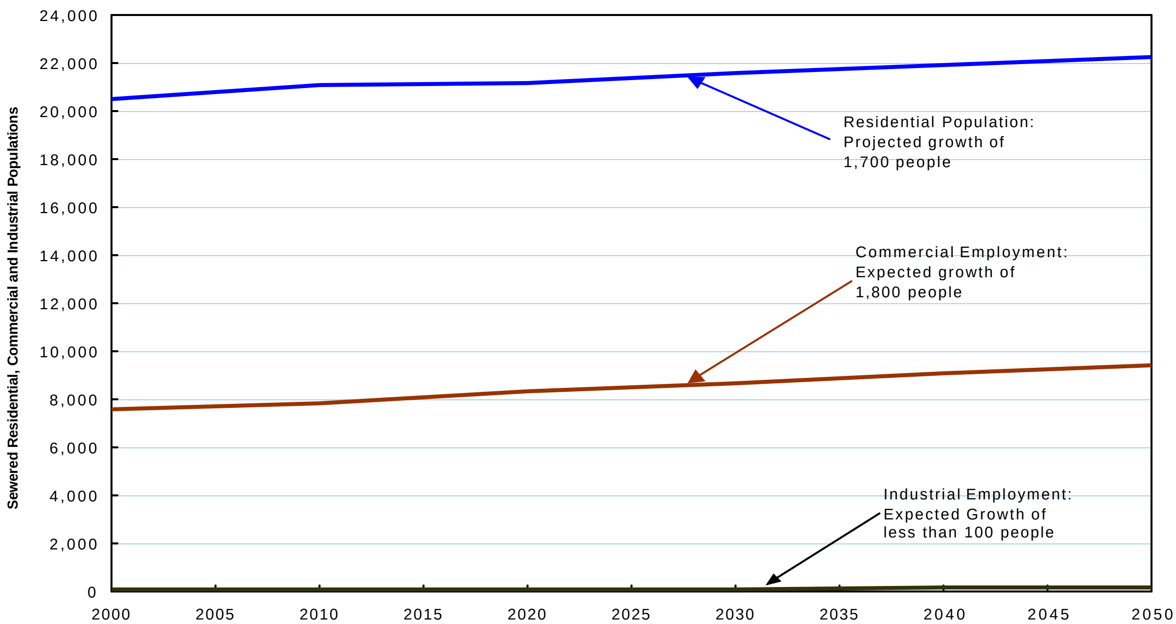

Figure 3. Refined residential population, commercial and industrial employment forecasts for the Service Area.

<u>Population Forecast Comparison for Service Area</u>

Revised population forecasts for the Service Area were derived from the *1999 Shoreline Comprehensive Plan* (*Shoreline Plan*) for comparison with KC WTD forecasts.

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[2] The Richmond Beach wastewater service basin differs from the Service Area by including areas of Shoreline that drain by gravity to the Lake Ballinger Pump Station.

[3] For TAZs that span the Service Area boundary, population is calculated (proportionately) according to the fraction of the TAZ within the Service Area

[4] Task 240 used wastewater basin-level forecasts while Task 250 used the more detailed TAZ-level population forecasts.

Appendix A of the *Shoreline Plan EIS* presents population forecasts for each of the neighborhoods in the City, for a 20-year window beginning in 1996[5]. The stated boundaries were used to determine which of the neighborhoods are located within the Service Area. Table 3 lists the city neighborhoods that fall within the Service Area along with baseline and forecasted residential populations, and Table 4 shows the KC WTD, *Shoreline Plan* and draft *Shoreline WMD Comprehensive Sewer Plan* population forecasts. In 2000, the *Shoreline Plan* forecasted residential population is 8 percent lower than the KC WTD forecasts. In 2016, the difference is one percent. The draft *Shoreline WMD* Comprehensive Sewer Plan residential population forecast is similar to the KC WTD forecast.

Table 3. Shoreline Comprehensive Plan residential population forecasts[a]

Neighborhood	Location	1996	2016
Richmond Beach	NW corner of city	4,661	5,345
Innis Arden	Western edge of city	1,284	1,303
The Highlands	SW corner of city	245	274
Hillwood	Northern edge of city; north of N. 185th St., west of Aurora Ave.	4,428	4,944
Richmond Highlands	Btw Aurora Ave. & Innis Arden E-W; Btw N. 165th St. & N. 185th St. N-S	4,512	4,990
Highland Terrace	East of Shoreline CC; bordered by Seattle Golf Club, Aurora Ave. and Westminster Way	2,436	2,916
Westminster Triangle	Southern edge of city along Westminster Way & Aurora Ave.	852	1,051
Total		**18,418**	**20,822**

a. These forecasts are for the entire Service Area: neighborhoods that drain to the Hidden Lake Pump Station and downstream neighborhoods served by the Richmond Beach Pump Station.

5 The population forecasts, which are reported in the *Shoreline Plan* in terms of dwelling units (DU), have been converted to residential population by assuming 2.4 residents per DU. This is the ratio of residents per DU used by the Shoreline WMD in its upcoming Comprehensive Sewer Plan. The City of Shoreline used PSRC's 1998 set of forecasts for its population and employment subarea forecasting.

Table 4. Refined population forecasts for Service Area[a]

Year	Residential	Commercial	Industrial
Task 250: Refined KC WTD Forecasts (based on PSRC TAZ data, June 1999)			
Year	**Residential**	**Commercial[c]**	**Industrial[c]**
2000	20,483	7,572	66
2010	21,019	7,840	70
2016	21,098[b]	8129[b]	81[b]
2020	21,151	8,322	88
2030	21,549	8,664	99
2040	21,885	9,038	110
2050	22,218	9,413	120
Task 250: 1999 Shoreline Plan Forecasts			
Year	**Residential**	**Commercial**	**Industrial**
1996	18,418	N/A	N/A
2000	18,899[b]	N/A	N/A
2016	20,822	N/A	N/A
Task 250: Draft Shoreline WMD Comprehensive Sewer Plan Forecasts[d]			
Year	**Residential**	**Commercial**	**Industrial**
2000	19,919	N/A	N/A
2016	21,569	N/A	N/A
2020	21,981	N/A	N/A

a. These forecasts are for the entire Service Area: neighborhoods that drain to the Hidden Lake Pump Station and downstream neighborhoods served by the Richmond Beach Pump Station.

b. The reported residential population is linearly interpolated from previous and following time periods in order to provide easy comparison to the other forecasted data set.

c. KC WTD's commercial and industrial population is based on the PSRC's forecasting by U.S. Dept. of Labor Standard Industrial Classification (SIC) codes using Washington State Employment Security Department records.

d. The draft Shoreline WMD Comprehensive Sewer Plan dated May, 3, 2000, reported forecasted residential populations of 36,151 and 39,941 for 2000 and 2020 for the Shoreline WMD coverage area. The baseline population is based on the number of Residential Customer Equivalents (RCE) recorded by the District (2.4 people per RCE), and the growth rate is based on PSRC's 1995 TAZ study. The populations shown above have been computed using the fraction of the Service Area within Shoreline WMD coverage area (assumes uniform spatial population distribution), plus 245 residents for the Highlands (102 DU and 2.4 people per DU).

The Shoreline Plan also contains employment forecasts based on local economic development policies and land use policies for each TAZ in the planning area. The TAZ baseline data and 20-year commercial employment forecasts are presented in a series of tables in Appendix B of the *Shoreline Plan EIS*. The Shoreline Plan forecasts 4,635 additional jobs throughout the city during the 20-year planning period beginning in 1996.

Given the planned rezoning along Aurora Avenue to encourage higher density commercial construction, a significant fraction of the new commercial employment will occur in the Service Area.

Population Forecast Comparison for the Area Tributary to Hidden Lake Pump Station

Table 5 contains KC WTD, *Shoreline Plan*, and Shoreline WMD population forecasts for the area tributary to the Hidden Lake Pump Station[6]. The Shoreline WMD forecasts shown here are part of the District's upcoming Comprehensive Sewer Plan. The Shoreline WMD forecasted population in 2020 is 17 percent higher than the KC WTD forecast. *Shoreline Plan* forecasted populations higher than the KC WTD forecasts, but lower than the Shoreline WMD forecasts[7].

The differences among the forecasts could simply result from the different analysis techniques. The Shoreline WMD Comprehensive Sewer Plan (draft) states that four separate population forecasts[8] were available for the District to derive its forecasts, but none of the data sources matched up with the District's boundaries, and that a more detailed analysis would be necessary to determine the population served by Shoreline WMD. Similarly, the KC WTD forecasts rely on TAZs that are larger in extent than some of the sub-basins tributary to the Hidden Lake Pump Station. As a result, populations forecasted for smaller sub-basins do not include local distributions of population, but are computed based on the population density for a larger area. Additionally, the PSRC forecasts, from which the KC WTD data are derived, are more appropriate for long-term system development and facility sizing rather than near-term forecasting in very small subareas.

[6] KC WTD population forecasts beyond 2020 are not included in Table 5 to make comparisons easier. See Table 4 for KC WTD forecasts beyond 2020.

[7] The Shoreline WMD Comprehensive Sewer Plan utilized PSRC's 1995 TAZ-level forecasts for population growth and its own recorded Residential Customer Equivalent (RCE) estimates for baseline population (2.4 people per RCE).

[8] Available forecasts: Washington State Office of Financial Management, the PSRC, the City of Lake Forest Park, the City of Shoreline (Phase II: 1998 TAZ-level study).

Table 5. Population forecasts for the Hidden Lake Pump Station tributary area[a]

Year	Residential	Commercial	Industrial
Refined KC WTD Forecasts (based on PSRC TAZ data)			
2000	10,672	5,632	62
2010	10,954	5,821	66
2016	10,996[b]	6,014	77
2020	11,024	6,142	84
2030	11,230	6,375	92
2040	11,407	6,632	105
2050	11,578	6,887	114
1999 Shoreline Plan Forecasts[c]			
Year	**Residential**	**Commercial**	**Industrial**
1996	10,580	N/A	N/A
2000	10,870[b]	N/A	N/A
2016	12,028	N/A	N/A
Draft Shoreline WMD Comprehensive Sewer Plan Population Forecasts			
Year	**Residential**	**Commercial**	**Industrial**
1995	11,275	N/A	N/A
2000	11,603[b]	N/A	N/A
2016	12,652[b]	N/A	N/A
2020	12,914	N/A	N/A

a. These forecasts are for the neighborhoods that drain to the Hidden Lake Pump Station (Shoreline WMD Basins 7, 10, 13, and 14, and the Highlands SD).

b. The reported residential population is linearly interpolated from previous and following time periods in order to provide easy comparison to the other forecasted data set.

c. Based on an analysis of neighborhood boundaries and a Shoreline WMD drainage map, the following neighborhoods listed in the *Shoreline Plan* are considered tributary to the Hidden Lake Pump Station: Highland Terrace, Hillwood (50%), Innis Arden (25%), Richmond Highlands, The Highlands, and Westminster Triangle.

PART III: IMPACTS OF INFILTRATION AND INFLOW REDUCTION

This section contains a general discussion of the potential impacts of infiltration and inflow reduction for the Hidden Lake Service Area. This discussion is applicable to all of the conveyance improvement alternatives developed in the Task 240 memo.

Two I/I reduction schemes are examined:

1. A 30 percent basin-wide reduction in the peak 20-year I/I as a benchmark based on the goals of the KC regional I/I program.

2. A higher level of targeted I/I reduction for its effectiveness in limiting the number of new facilities to be constructed.

I/I Reduction in the Service Area

Infiltration and inflow account for about 86 percent of 5-year peak flow and 89 percent of the 20-year peak flow in the Service Area's wastewater conveyance system, based on the projections of the KC WTD calibrated I/I model (Table 6). During wet season storms, the existing conveyance facilities' capacities are periodically exceeded by I/I, resulting in sanitary sewer overflows (SSOs). According to KC WTD, there is currently an average of three SSO events each year[9] at the Hidden Lake Pump Station wet well, rather than the one event per 20 years KC standard. Hidden Lake Pump Station overflows are directed to Shoreline WMD Pump Station No. 4, where approximately 75 percent are controlled and pumped back to the Hidden Lake Pump Station. The other 25 percent of overflows discharge to Puget Sound. Downstream of the Hidden Lake Pump Station, there is a designed overflow at manhole 7A of the Boeing Creek Trunk and there have been reports of overflows at other manholes along the trunk (see Task 210 report).

Table 6. I/I Contribution to peak flows at the Richmond Beach Pump Station[a]

	Peak Flow (mgd)	I/I Flow (gpad)	I/I Flow (mgd)	% Attributable to I/I
5-Year Storm Event	15.2	4,530	13.0	86
20-Year Storm Event	19.9	6,160	17.7	89

a. The flow projections were provided by KC WTD for the year 2050. These estimates account for sewer deterioration by assuming a seven percent per decade increase in I/I for three decades through 2030. The updated flow projections from the previous section are incorporated upstream of Hidden Lake. The flow projections downstream of Hidden Lake were not updated because no new flow data were collected and analyzed for this part of the collection system.

Basin-Wide 30 Percent I/I Reduction

The Task 240 report described alternatives for conveying and/or storing the 20-year peak flow but did not address how I/I reduction could impact the size of facilities required for

[9] This estimate includes hydraulic capacity related overflows and overflows resulting from mechanical failures.

controlling SSOs. This section describes the benefits of I/I removal, using a 30 percent reduction in peak flow as a benchmark and provides preliminary cost information based on previous Brown and Caldwell projects. In addition, this section identifies field data acquisition to be considered during project predesign. The discussion here is general and applies to all alternatives described in Task 240.

Task 240 established that the capacity of the KC WTD pump stations and trunk sewer is substantially less than the projected 20-year peak flow in the Hidden Lake Service Area. Table 7 shows the projected 20-year peak flow at the Hidden Lake and Richmond Beach Pump Stations, and along the Boeing Creek Trunk without I/I reduction and following a 30 percent reduction of I/I.

Table 7. Impact of I/I reduction on existing facilities

Reach	Length (ft)	Design Flow[a] (mgd)	20-Year Peak Flow (mgd)	20-Year Peak Flow After 30% I/I Red. (mgd)	Excess Flow (mgd)[c]
B00-49 to HLPS	2,803	5.9	11.9	8.4	2.5
HLPS to B00-38	2,375	3.8[b]	13.2	9.2	5.4
B00-38 to B00-29	2,476	7.4	14.3	10.0	2.6
B00-29 to B00-23	3,316	5.5	14.9	10.4	4.9
B00-23 to B00-17	2,260	6.1	18.2	12.7	6.6
B00-17 to B00-04	3,718	9.6	19.1	13.4	3.8
B00-04 to RBPS	872	7.8	19.9	13.9	6.1
RBPS	N/A	10.4	19.9	13.9	3.5

a. Design flow calculated with Manning's equation using friction factor, n = 0.013

b. Equal to the pumping capacity of the Hidden Lake Pump Station.

c. Excess flow after 30 percent I/I reduction.

Removing 30 percent of the peak wet weather I/I would help reduce the frequency of overflows, but I/I model projections show that SSOs would still occur an average of once per winter. To meet the KC standard of one overflow per 20 years, new facilities would be required in addition to a 30 percent reduction in I/I.

Attempting a Higher Level of I/I Reduction

A more ambitious I/I control program could be instituted in an effort to avoid constructing new facilities and/or adding capacity to existing facilities. Table 8 shows the design capacity and projected 20-year flow in specific reaches of the Boeing Creek Trunk, similar to Table 7. Table 8 also shows the fraction of I/I that would need to be removed in order to limit the 20-year peak flow to the existing capacity of the conveyance system. The amount of I/I removal needed to eliminate excess SSOs is generally higher than 50 percent and as high as 71 percent for one reach[10].

Table 8. No capacity upgrades–I/I removal target

Reach	Length (ft)	Design Flow[a] (mgd)	20-Year Peak Flow (mgd)	% Removal Requred	I/I Rate Remaining (gpad)
B00-49 to HLPS	2,803	5.9	11.9	50	3,867
HLPS to B00-38	2,375	3.8[b]	13.2	71	1,404
B00-38 to B00-29	2,476	7.4	14.3	48	3,028
B00-29 to B00-23	3,316	5.5	14.9	63	1,947
B00-23 to B00-17	2,260	6.1	18.2	66	1,674
B00-17 to B00-04	3,718	9.6	19.1	50	2,819
B00-04 to RBPS	872	7.8	19.9	61	2,041
RBPS	N/A	10.4	19.9	48	2,946

a. Design flow calculated with Manning's equation with friction factor, n = 0.013

b. Equal to the pumping capacity of the Hidden Lake Pump Station.

An I/I control plan for the Service Area could also include roof and foundation drain disconnection, catch basin interconnection removal, manhole rehabilitation and sewer main rehabilitation. An accurate estimate of the costs of this level of rehabilitation cannot be developed without extensive flow monitoring, source detection, and the development of unit costs for I/I removal.

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10 The significance of the removal estimates in Table 7 can be understood by comparison with a previous I/I rehabilitation project performed by the Lacey, Olympia, Tumwater, Thurston County (LOTT) Wastewater Partnership *(LOTT Basin OL22 I/I Removal Effectiveness Evaluation Memorandum*; Brown and Caldwell, 1999). During the summer of 1997, the City of Olympia completed a rehabilitation of manholes and sewers located in the public right-of-way in the 130-acre, LOTT Basin OL22. A total of 18.2 inch-diameter miles of sewer mains (63 percent of basin total) and 195 lower side sewers from the sewer main to the property line (73 percent of basin total) were replaced. The results of flow monitoring and analysis using hydrologic simulations indicated only a 17 percent drop in the 20-year peak flow. If rehabilitation in the public right-of-way within the Hidden Lake Service Area yielded a similar 17 percent reduction in the 20-year peak flow, the peak storm flows would still be greater than the conveyance system capacity.

The LOTT results are supported by the finding in the *Bryn Mawr Infiltration/Inflow Field Investigation and Project Identification Study* (Brown and Caldwell, 1998) that the majority of peak I/I enters the conveyance system through connections or sewer defects on private property. The costs associated with I/I removal from private property would be substantial. There are approximately 5,000 private sewer connections in the Hidden Lake Service Area. The low-bid contractor for the Bryn Mawr Project estimated a cost of $7,000 per household for side-sewer replacement from the house connection to the sewer main (including surface restoration).

Much of the necessary I/I reduction activity would occur on private property and would probably require adopting and enforcing a municipal ordinance. The responsibility for any I/I prevention ordinances falls on the local sewer agencies: the Shoreline Wastewater Management District and the Highlands Sewer District. Private lateral sewer replacement and foundation drain disconnection would involve digging up property owners' landscaping to install new piping. The County is currently working with these agencies as part of the King County Regional I/I Control Project to assess the amount of I/I, select pilot projects to evaluate I/I control measures, and develop an equitable regional program to reduce I/I.

Rehabilitating a large enough portion of Service Area sewers to avoid all facility upgrades would cost more than building new facilities to convey the 20-year peak flow. However, targeted I/I reduction could be used in combination with other control strategies to delay and/or reduce the size of new facilities. Where appropriate, the alternatives described in the following section include an evaluation of targeted I/I reduction.

PART IV: EVALUATION OF ADDITIONAL ALTERNATIVES

In previous CSI project team meetings, there had been a clear preference for Alternative C2 (diversion pump station and sewer) over the other alternatives developed for Task 240. However, in a meeting held on December 2, 1999, County staff felt all possible improvements had not been examined. Given the level of capital expenditure necessary to control overflows in the Service Area, the feasibility of additional alternatives was to be measured against Alternative C2. There was also direction to examine a phased project implementation that could successfully coordinate with ongoing King County projects in the area, and level capital costs. This section contains an evaluation of the feasibility of five additional alternatives that were identified by the CSI project team and other KC staff.

Alternative D5. Using Primary Clarifiers for Storage at the Richmond Beach Pump Station

The consultant team was instructed to examine the feasibility of a variation on Alternative B2 that would use the abandoned (and currently filled in) primary clarifiers at the former Richmond Beach Treatment Plant for storage. A total storage volume of 1.5 MG would be required at this location, and if a large enough portion of the storage were provided by the clarifiers, there could be a significant cost savings. According to KC WTD personnel, the clarifiers were not dismantled during the Richmond Beach Flow Transfer Project, although the top few feet of the vertical walls were probably damaged.

In order to provide a significant cost savings, the clarifiers would need to:

- Remain structurally sound and capable of storing sewage after excavation.
- Provide a large enough fraction of the required storage at a low enough cost to make this alternative significantly less costly than the Richmond Beach storage alternative evaluated in Task 240 (Alternative B2).

The dimensions of the two rectangular clarifiers were given in Table 4-2 of the *Richmond Beach Treatment Plant Secondary Treatment Facilities Predesign Report* (May, 1987) and are reproduced here in Table 9.

Table 9. Dimensions of Richmond Beach Treatment Plant primary clarifiers

Length	95.67 ft
Width	16.5 ft
Average Depth	8.5 ft
Number of Clarifiers	2
Total Volume of Two Clarifiers	**200,743 gal**

Because the clarifiers could only provide a small fraction of the 1.5 MG storage required, Alternative D5 has no significant advantages over the alternative on which it is based, Alternative B2. Part I of this report detailed the shortcomings of Alternative B2. Since Alternative D5 does not resolve the previously noted problems with storage at the Richmond Beach Pump Station (see Part I: Review of Task 240 Project Team Meeting), it is not a feasible solution.

Alternative D6. Redirecting Part of Shoreline WMD Basin 14, Reducing Size of New Pump Station

Alternative C proposed to build a new pump station and force main to convey the wastewater generated in Shoreline WMD Basin 14 to the north and out of the Hidden Lake Service Area. Alternative D6 is similar to Alternative C, the key difference being a change to the piping alignment that reduces the size of the new pump station and force main.

The change in piping alignment would occur in the northern portion of Shoreline WMD Basin 14. Presently this area drains southward by gravity to the upstream end of the Boeing Creek Trunk (where the new pump station would be located). Alternative D6 would redirect a portion of the local collection system to connect with the new force main at the gravity transition point. This would reduce the required pumping capacity of the new pump station and size of the force main, resulting in a potential cost savings on these facilities.

The most likely scenario would divert wastewater from Shoreline WMD manhole DK1 (Richmond Beach Road, 300 ft east of 1st Avenue NW) westward to 8th Avenue NW. The diversion pipe would discharge into a force main to gravity transition manhole at Richmond Beach Road and 8th Avenue NW. A gravity sewer would carry wastewater to the north and out of the basin.

Manhole DK1 is located a short distance upstream of flow monitoring manhole J25. There are only a couple of streets that drain to J25, but not DK1, so the flow estimates for J25 are a good indication of flow at DK1. The current estimated 20-year flow for J25 is 1.66 mgd (see Table 2). Therefore, any diversion could be expected to reduce the wastewater flow at the new pump station by a similar amount.

The feasibility of this alternative has been examined using a map of local agency sewers and the best topographic data available. To support this evaluation, the KC WTD GIS group prepared a set of 2 ft contours, based on a digital elevation model (DEM) with 10 meter by 10 meter pixels[11].

An examination of the contour map shows that the local topography varies along the proposed diversion route, so that portions of a gravity sewer would need to be constructed relatively deep. The following describe the two sections of the proposed pipe:

- The section of Richmond Beach Road between manhole DK1 and 8th Avenue NW rises from an elevation of 395 ft to 421 ft between 2nd and 3rd Avenues NW, before dropping to an elevation of 393 ft at Richmond Beach Road and 8th Avenue NW. In order to flow by gravity, the diversion sewer would need to reach of maximum depth of more than 25 ft below the ground surface. While open-trench construction to a depth of 25 feet is technically feasible, it is more challenging and expensive than shallower open-trench pipeline construction. As an alternative to open-trench construction, a directional drill could potentially be used to construct a small-radius tunnel over the 2,000 ft distance between manhole DK1 and 8th Avenue NW. If this alternative were preferred, the more appropriate construction technique for the diversion sewer could be determined after a detailed analysis of construction issues and costs in predesign.

- The ridge line delineating the northern boundary of the Service Area crosses 8th Avenue NW near NW 200th Street. The ground surface slopes gently upward from an elevation of 393 ft at the proposed force main to gravity transition point to 424 ft at the ridge line. Beyond the ridge line, the ground surface slopes downward to the north. The maximum depth of a gravity sewer would preclude this use of open-trench construction on this section of pipe as well. A directionally drilled tunnel would need to be between 5,500 and 6,000 feet long for gravity flow beyond the ridge line and out of the Service Area.

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[11] The DEM was prepared by the US Geological Survey. It has an absolute vertical accuracy of 7 m, but the relative (i.e. pixel-to-pixel) vertical accuracy is much higher.

This alternative should be considered only if it could be combined with other mitigation strategies to eliminate the need for a new pump station.

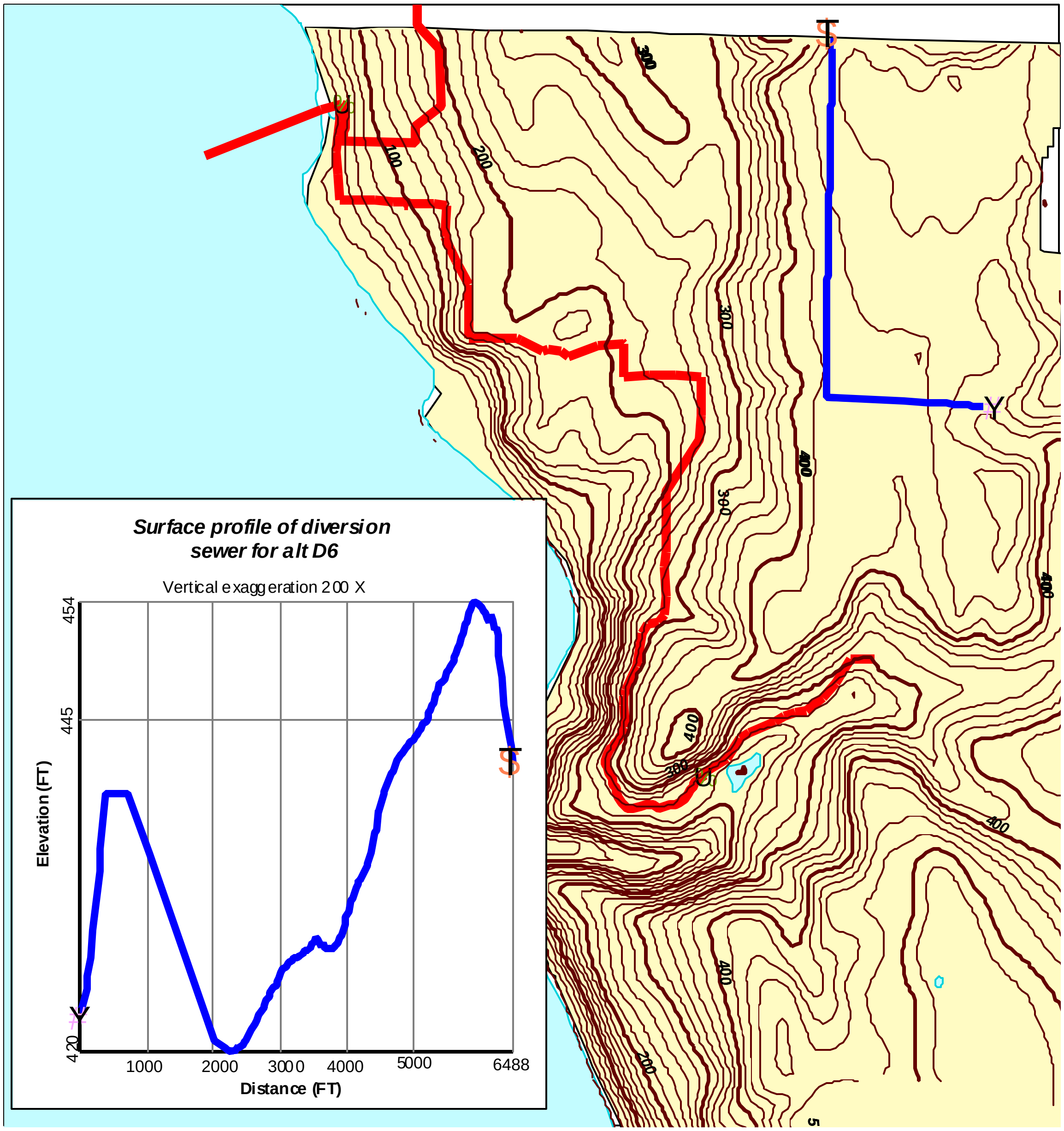

Figure 4: Alternative D6

Route and Surface Topography for Diversion Sewer

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Legend
- Diversion Sewer
- KC Pump Stations
- KC Conveyance Lines
- Hidden Lake Study Area

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King County Department of Natural Resources

700 0 700 1400 2100 Feet

January 28, 2000

Alternative D7. Tunnel storage and conveyance

Alternative D7 proposed to construct a 10 to 14-foot diameter tunnel from either manhole B00-49 or the Hidden Lake Pump Station to the Boeing Creek Trunk in the vicinity of the inverted siphon forebay (B00-29). The tunnel would allow enough storage to control the 20-year design storm at the Hidden Lake Pump Station. The outlet of the tunnel would be regulated to limit overflows downstream of its connection with the Boeing Creek Trunk.

A quick evaluation of the proposed routes showed that the Hidden Lake Pump Station elevation is lower than the proposed outlet at B00-29. This route is therefore not possible without pumping, and is not considered further. The elevation difference between manholes B00-49 and B00-29 is sufficient for gravity flow.

Constructing a tunnel solely in the public right-of-way would not be possible in this area, because tunneling machines have large turning radii (~900 feet), and would not be able to follow the turns of the winding, local streets. A number of access shafts could be dug to allow the tunneling machine to be lifted out and reoriented, but the depth of the tunnel (> 100 ft) and the density of local housing would make this option unacceptable.

The tunnel would have to be routed under more than a dozen private properties. The County would need to acquire easements from property owners prior to tunnel construction[12]. As the number of required easements increases, further evaluation of the potential risks would have to be performed. The feasibility of this alternative will depend in large part on the construction costs, technical challenges, and the anticipated difficulties associated with obtaining easements for tunnel construction under private property.

Table 10 lists the construction and project costs associated with two recent KC tunneling projects: the West Seattle Tunnel (bid 1994) and the Denny Way/Lake Union CSO Control Project (bid 1999). The costs of the West Seattle Tunnel are scaled up from a mid-1994 Engineering News Record (ENR) Seattle Construction Cost Index of 5,650 to the value of 7,000 that was used in Task 240.

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[12] Although tunneling easements under private property are more difficult and costly to obtain, easements were obtained for two properties prior to construction of the King County WTD West Seattle Tunnel. The tunnel was constructed under a corner of each property, well away from the houses. Settlement monitors were installed prior to and after construction and no ground settling was observed.

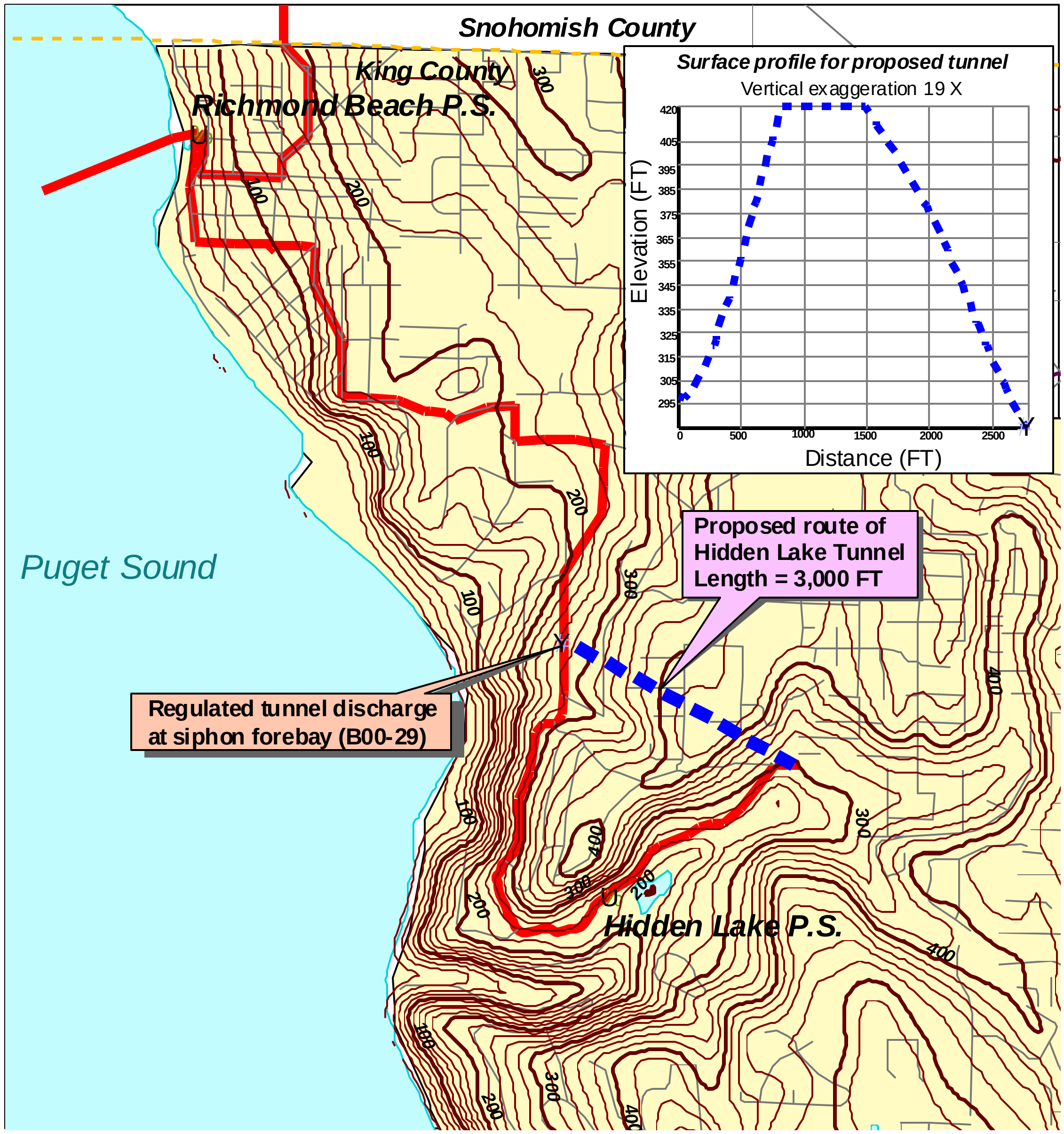

Figure 5: Alternative D7

Hidden Lake Storage Conveyance Tunnel

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Legend
- Siphon Forebay B00-29
- County Boundary
- Contour Lines
- Streets
- KC Pump Stations
- KC Conveyance Lines
- Hidden Lake Study Area

500 0 500 1000 1500 2000 Feet

February 3, 2000

Table 10. Construction and project costs for King County tunneling projects

	West Seattle Tunnel[a]	Denny Way/Lake Union Tunnel
Length	10,200 ft	6,200 ft
Diameter	13.1 ft	14.7 ft
Construction Cost	**$27.3 million[b]**	**$29.3 million**
Mobilization/ Demobilization (10%)[c]	$2.7 million	$2.9 million
Design and Owner Management (35%)[c]	$9.5 million	$10.3 million
Total Project Cost[c]	**$39.5 million**	**$42.5 million**

a. The West Seattle tunnel required easements for construction under two properties (see footnote 5).

b. Original construction cost of $22 million was scaled up from 1994 to 1999 dollars to be consistent with the Task 240 report. ENR Seattle CCI (1994) = 5,650; ENR Seattle CCI (1999) = 7,000

c. Mobilization/demobilization, design and owner management costs were added to the construction cost to compute a total project cost. This is consistent with the cost estimates provided in the Task 240 report.

The Hidden Lake Tunnel would be approximately 3,000 feet in length. Assuming the Hidden Lake Tunnel would have a range in cost per foot to the West Seattle and the Denny Way/Lake Union Tunnel ($3,900 to $6,800), and if the cost of rebuilding the Hidden Lake Pump Station is included, Alternative D7 costs would be similar to the alternatives examined in Task 240.

There are more uncertainties in cost and construction challenges with tunnel sewers than with open-trench sewers. Since there would probably be very little cost and/or operations and maintenance savings over Alternative C2 (diversion pump station and sewer), this tunneling/storage alternative should only be considered further if there are other issues, policy or otherwise, that would make tunnels preferable.

Alternative D8. Short-Term Solutions to Reduce SSO Frequency Until the North Treatment Plant has been Sited

This alternative uses a combination of short-term remedies to reduce the number of system overflows in the Service Area. The level of SSO control would initially target the once in 2-years or 5-years peak flow. Then, after a site for the North Treatment Plant is chosen, a program of facilities improvements and/or I/I reduction would be enacted to meet the KC standard of one overflow per 20 years. By initially seeking short-term solutions to system overflows, this alternative would seek to maximize the use of existing facilities and delay constructing costly facilities that may be underutilized after the North Treatment Plant is in operation. The feasibility of this alternative will depend on whether suitable control measures can be adapted quickly and cost-effectively, and whether the short-term solutions provide long-term flexibility.

To coincide with the scheduled startup date for the North Treatment Plant, the planning horizon for this alternative is 2010, rather than 2050 as was used in other alternatives. An interim solution might include a combination of I/I reduction, inline storage, additional conveyance capacity, and treatment of SSO discharges. The reduction in peak flows required to control the 2- or 5- year peak flow was determined and is described in Table 11. The projected 5-year peak flow for 2010 is similar to the value for 2000 given in Table 1, but also includes additional base flow due to population growth and a 7 percent increase in I/I for sewer degradation through 2030.

A scenario for controlling the 2-year peak flow was developed to test the feasibility of enacting a short-term solution. The 2-year peak flow is 3.0 mgd higher than the current maximum pumping capacity of the Hidden Lake Pump Station. The 5-year peak flow is 4.4 mgd higher than the current maximum pumping capacity of the Hidden Lake Pump Station.

This excess flow at the Hidden Lake Pump Station would have to be removed either by storage or I/I reduction if downstream facilities upgrades are to be kept to a minimum. Regardless of the mitigation upstream of Hidden Lake, there are periodic overflows from Boeing Creek Trunk manhole 7A that would need to be addressed. Manhole 7A is downstream of the "buried utilities" area described in Task 240, so no known construction factors would complicate adding capacity to the trunk downstream of manhole 7A.

Table 11. Sub-Basin flow-tributary to Hidden Lake Pump Station for 2010[a]

Basin	Area (ac)	Base Flow (mgd)	2-yr I/I (gpad)	2-yr Peak Flow (mgd)	5-yr I/I (gpad)	5-yr Peak Flow (mgd)
J25[b]	200	0.10	4,000	0.90	5,340	1.17
J7 (lower)[b]	150	0.08	1,530	0.31	2,600	0.47
J7+J25[b]	350	0.18	2,940	1.21	4,100	1.61
D4[b]	350	0.36	5,460	2.27	6,810	2.73
Unmonitored Basin 14[c]	600	0.31	3,100	2.17	4,100	2.77
Basin 7 (unmonitored)[d]	50	0.01	N/A	0.26	N/A	0.26
HSD & Basin 13 (unmonitored)[d]	400	0.04	N/A	0.86	N/A	0.86
Totals:	**1,750**	**1.08**		**6.8**		**8.2**

a. Flow projections are based on values provided by KC WTD. The estimated sewered area is lower than in the Task 240 report, because some unsewered areas within Basin 14 (e.g. parks) were removed.

b. These sub-basins are contained in Shoreline WMD Basin 14 and have been flow monitored.

c. I/I flows for unmonitored areas are set equal to the sub-basin J7+J25 I/I rates. The land use patterns for the unmonitored basins are more similar to those of sub-basins J7+J25 than sub-basin D4.

d. Peak flows are set equal to the capacity of Shoreline lift stations 4 and 5.

Controlling the 2-Year Storm Until 2010 with I/I Reduction

If I/I reduction were used to reduce peak flows, the most cost-effective method of rehabilitation would be to concentrate on portions of the collection system with the highest I/I. Of the monitored portions of Shoreline WMD Basin 14, the highest I/I was measured at local manhole D4. The 2-year peak I/I is estimated at 5,460 gpad. Previous documented Brown and Caldwell experience suggests that rehabilitation including private lateral and sewer main replacement can reduce the peak I/I by up to 70 percent. Assuming a similar 70 percent reduction could be realized in the Service Area, the post-rehabilitation I/I upstream of manhole D4 would be reduced to 1,820 gpad, a reduction of 1.90 mgd. Approximately 600 acres of Basin 14 has not been isolated by flow monitoring. If we assume that half of this area has I/I rates similar to the sewers upstream of D4, an additional 1.1 mgd could be removed by full rehabilitation.

Rehabilitating the private and public sewers upstream of local manhole D4 and an additional 300 acres with similar I/I rates could reduce I/I enough to control the 2-year storm until the North Treatment Plant begins operation in 2010. The area tributary to D4 includes commercial and multifamily housing which are typically more expensive to rehabilitate per acre than single family residential areas[13]. Beyond this initial cost, there would be the additional expense of upgrading the conveyance system once the new treatment plant comes online, and extending the planning window out to 2050. In addition to the I/I reduction, the hydraulic constriction downstream of manhole 7A must be removed. A total of 2,000 feet of pipe would be replaced at an approximate cost of $1 million. As part of the phased approach, KC may also install an interim wet weather treatment device along the Hidden Lake Pump Station overflow line, such as a Continuous Deflective System (CDS) to reduce the volume of solids and floatables discharging to Puget Sound when overflows occur.

Controlling the 5-Year Storm Until 2010 with I/I Reduction

Reducing the peak 5-year flow to the capacity of the Hidden Lake Pump Station by I/I reduction would be more challenging than controlling the 2-year peak flow, and would require rehabilitation in a greater portion of the Service Area. Assuming that replacing lateral and main sewers would remove 70 percent of peak I/I, all of Basin 14 would require rehabilitation, with the exception of lower portion of the basin isolated by manhole J7 (see Figure 2). The rehabilitation would cover 1,500 acres. Since the majority of the rehabilitation would occur in residential areas, the per acre cost would probably be less than rehabilitating the area above manhole D4, which is primarily composed of commercial properties and mixed use housing. Assuming an average cost of $20,000 per acre, it would cost approximately $30 million to reduce the 5-year peak

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[13] Previous documented Brown and Caldwell experience suggests than the sewer rehabilitation would cost approximately $25,000 per acre. Rehabilitating 650 acres would therefore cost approximately $16.25 million. These costs are based, in part, on Olympia costs for lateral sewer and main sewer replacement, and Bryn Mawr lateral replacement. The per acre cost of lateral replacement can be widely variable and depends on the number of connections per acre, and the amount of surface restoration required.

flow to the current capacity of the Hidden Lake Pump Station by rehabilitating sewers in Shoreline WMD Basin 14. Adding capacity downstream of manhole 7A would also be required. Given the cost of controlling the 2-year peak flow with I/I reduction alone, a phased project with this level of I/I control, plus additional conveyance facilities (similar in alignment but smaller in size than those in Alternative C) to control the 20-year peak flow, would be more costly than Alternative C2 (diversion pump station and sewer). Targeted I/I control, however, may form a part of a phased solution that would include storage and expanded conveyance facilities. This phased alternative would also serve to work toward compliance with KC policy objectives while maximizing the use of existing facilities.

Controlling the 2-Year Storm with Inline Storage, or Inline Storage and I/I Reduction

Limiting overflows to once per 2 years (until 2010) by I/I reduction alone would have significant costs. Another approach would utilize storage, possibly combined with I/I reduction. It is assumed that all storage would be inline, i.e. a large diameter pipe. Two scenarios are examined in this section.

1. Rehabilitate the 350 acres upstream of Shoreline manhole D4, and install 0.1 MG of inline storage to control the two-year storm. A combination of additional conveyance capacity, storage, and/or I/I removal would be required beyond 2010.

2. Construct a 0.5 MG inline storage pipe near manhole B00-49 to control the two year peak storm until 2010. Beyond 2010, a comprehensive solution would be required to meet the KC standard of one overflow every 20 years.

The combination of inline storage and I/I reduction evaluated consists of a 300 foot long section of 8 foot diameter pipe and rehabilitation of the 350 acres upstream of Shoreline manhole D4. A preliminary analysis of costs suggests the sewer rehabilitation costs would be approximately $8.75 million (assuming a cost of $25,000 per acre), and the storage pipe would be approximately $0.7 million. Adding additional capacity downstream of Boeing Creek Trunk manhole 7A and installing a Continuous Deflective System on the Hidden Lake overflow line would bring project costs close to $11 million. A number of new facilities would also be required after 2010 for a long-term solution to controlling system overflows to the KC standard.

The *storage only* solution could consist of a 1,500 foot long section of 8 foot diameter pipe. The upstream end of the Boeing Creek Trunk is a potential location for this pipe. Construction factors, such as the width of the street under which the pipe would be installed and impact of construction on local traffic, and the depth of the existing sewers, may affect the feasibility of the project. A preliminary analysis of piping and installation costs suggests the storage pipe would cost of between $3 and $3.5 million (project cost, ENR Seattle CCI 7000). Adding capacity downstream of manhole 7A and placing a Continuous Deflective System unit on the Hidden Lake overflow line would bring total project costs to approximately $5 million.

This interim solution would cost less than the I/I reduction scenarios above. The storage solution only controls the 2-year storm, and is only sufficient until 2010. Many of the same facilities proposed in Task 240 would be required for a long-term solution, if sufficient flow reduction is not obtained through the County's regional I/I control program.

Controlling the 5-Year Storm with Inline Storage, or Inline Storage and I/I Reduction

To control the 5-year peak flow until the North Plant is operating in 2010 requires reducing the peak flow at the Hidden Lake Pump Station from 8.2 mgd to 3.8 mgd. To accomplish this peak flow reduction by storage alone would require a tank or storage pipe with one million gallons of capacity. The planning level assessment of the area upstream of the Hidden Lake Pump Station suggests that 0.5 MG of storage could be accommodated in a gravity in/gravity out configuration. The feasibility of providing 1 MG of storage must be evaluated with further site investigations during project predesign. A preliminary estimate of offline storage costs ranges from $5.5 to $6.0 million (project cost, ENR Seattle CCI 7000), plus an additional $1.5 to $2.0 million for pipe improvements downstream of overflow manhole 7A and placing a Continuous Deflective System unit on the Hidden Lake Pump Station overflow line to capture floatables.

Assuming storage were limited to 0.5 MG, an additional 1.4 mgd of peak flow must be removed by I/I reduction. This could be accomplished by targeting 300 acres of the area upstream of local manhole D4 (see Figure 2 for location) for a 70 percent reduction in peak 5-year I/I (from 6,820 gpad to 2,050 gpad). Assuming the rehabilitation costs an average of $25,000 per acre (some residential and commercial land use), rehabilitating 300 acres costs $7.5 million. Together with storage, improvements downstream of overflow manhole 7A and floatables control on the Hidden Lake Pump Station overflow line, the total cost of this interim solution is estimated at $12.5 million

The phased solutions presented in this section are only a selection of possible strategies, and the costs presented are preliminary and subject to further investigation. Other combinations of I/I reduction, increased conveyance and storage could be developed for meeting the immediate goal of reducing SSOs in the Service Area, the long-term goal of meeting the KC standard of one overflow per 20 years, and providing the flexibility to adapt to the North Plant location and the results of the regional I/I study.

Alternative D9. Phasing Portions of Alternative C Construction on an As-Needed Basis

The evaluation of alternatives in Task 240 and previously in this document suggests Alternative C (diversion pump station and sewer) is a promising solution for meeting present and future wastewater conveyance needs in the Service Area. However, there are two major King County projects that will have an effect on Alternative C: the regional I/I program and the siting of the North Treatment Plant. This section examines the specific impacts these projects will have on Alternative C and whether cost savings may be realized by phasing elements of Alternative C construction without compromising the 20-year design standard.

Between winter 2000 and 2004, the KC regional I/I program will monitor local and regional system flows to assess I/I impacts on the King County conveyance system. A number of pilot I/I reduction projects will be conducted throughout the County during the project. Flow monitoring and analysis will help refine our understanding of I/I rates in the Service Area, and the pilot projects will refine our understanding of the effectiveness of I/I removal methods. The final report will be completed in 2004, at which time the conveyance system improvements for the Service Area would be designed. If this area were selected for one of the Regional I/I Control pilot projects, construction of a small representative rehabilitation project in the Service Area could be completed by winter 2002. The flow data collected during the regional I/I study will help provide greater confidence in the Service Area conveyance system design flows.

The location of the North Treatment Plant will affect the sizing or even the need for some of the conveyance facilities proposed in various alternatives. The following are examples of specific elements of Alternative C that may be impacted by the location of the new treatment plant.

- While most of the facilities proposed in Alternative C are required immediately, the additional capacity on the Richmond Beach - Edmonds Interceptor would not be needed until after 2010. If the North Treatment Plant is located at Point Wells or to the north of Lake Washington, the Richmond Beach - Edmonds Interceptor may not be needed. Construction along this interceptor could be avoided, resulting in a cost savings of between $1 and $2 million.

- The new pump station to be located near manhole B00-49 would house several pumps, and need an ultimate pumping capacity of 13.2 mgd, according to the updated flow projections. The station pump house should be constructed large enough for the ultimate flow, with pumps to be added on an as-needed basis.

- According to the current schedule, North Treatment Plant siting should be completed by the end of 2002. At that time, the Hidden Lake conveyance system improvements preliminary design will be completed, with final design not yet finished. Because Alternative C was designed to be flexible in response to the plant siting, the layout of the new force main/gravity sewer could be adjusted for cost savings after the plant is sited. If the treatment plant is sited prior to Hidden Lake design, adjustments could be made without disrupting the Hidden Lake schedule. Because of the frequency of overflows at the Hidden Lake Pump Station (either storm induced or mechanically caused), however, it is not recommended that the Hidden Lake Pump Station project be delayed.

PART V: REVIEW OF HIDDEN LAKE DECISION WORKSHOP AND DESCRIPTION OF THE WORKING ALTERNATIVE

The consultant team was instructed to prepare alternatives that involved phased construction and combinations of demand management, storage and increased conveyance. The additional phased/combination alternatives were presented to KC staff at a decision workshop held on March 16, 2000. The objective of the workshop was to specify a working alternative that would meet the immediate upgrade needs at the Hidden Lake Pump Station, reduce the number of sanitary overflows in the service area, and achieve the KC 20-year control level (see Appendix B for meeting notes; Appendix C for presentation slides).

The workshop began with a description of the current level-of-service problems in the Service Area, a review of future flow projections, and a recap of the alternatives that had been previously developed. Following the review of previous work, additional alternatives emerged by combining the following elements:

- Increasing the conveyance capacity along the existing corridor
- Incorporating storage to attenuate peak flows
- Managing demand by reducing I/I and/or reducing the amount of sewer deterioration
- Constructing a pump station and diversion sewer to carry peak flows away from the Boeing Creek Trunk

Working Alternative

The working alternative would initially retrofit or replace the Hidden Lake Pump Station to achieve a peak pumping capacity of 5.5 mgd, and parallel or replace a total of 6,400 lineal feet of the most capacity limited sections of the Boeing Creek Trunk[14]. Increasing the pumping capacity at Hidden Lake and removing the bottlenecks in the Boeing Creek Trunk would allow the full capacity of the 10.4 mgd Richmond Beach Pump Station to be used. This combination of upgrades would reduce the number of storm related overflows to approximately one every 2 years. Providing 0.5 MG of storage upstream of the Hidden Lake Pump Station would, according to the best available flow information, further reduce the number of storm related overflows to one every 4 to 5 years. After the North Plant siting and regional I/I programs are completed (assumed 2005), the level of control would be brought to the KC standard of one overflow every 20 years by I/I

[14] Increasing the capacity of the Hidden Lake Pump Station from 3.8 mgd to 5.5 mgd and upgrading the downstream conveyance brings the capacities of these facilities in line with the Richmond Beach Pump Station. Both upgrades are essential to reducing overflows until the 20-year control plan is implemented. Increasing the capacity of the trunk sewer will reduce overflows at manhole 7A. Rebuilding or retrofitting the Hidden Lake Pump Station with a 5.5 mgd capacity will reduce the frequency of overflows from the wet well, while limiting force main velocities to 8 ft/s. All facilities would have sufficient capacity for the unattenuated 2-year peak flow.

reduction, additional storage and/or construction of a diversion pump station and sewer directed away from the Boeing Creek Trunk. The final flow projections and treatment plant location would be used for sizing and alignment of the new facilities.

This alternative provides:

- Short-term improvements that will reduce the frequency of overflows and long-term improvements will incorporate better flow projections and routing information.
- Time for the regional I/I program to work. Rather than accepting all flows from the component agencies, the County can work with these agencies to promote I/I control and system maintenance to manage peak flows.
- Expanded capacity in the Boeing Creek Trunk that will allow the Richmond Beach Pump Station to be fully utilized.

The decision to retrofit the Hidden Lake Pump Station or replace it with an adjacent pump station (possibly where the driveway is currently located) will be made after performing a detailed analysis in project predesign. The predesign team must investigate if larger pumps that meet the new design head and flow conditions could fit within the existing layout, and if these pumps could pump slowly enough to pass dry weather flows with continuous operation (i.e. alleviate current cycling problem). New electrical, instrumentation and control equipment will be necessary whether retrofitting or replacing the station. The amount of work involved and the necessity of maintaining operation of the pump station during construction may require that the existing station to be replaced. The cost estimates prepared in this section assume the Hidden Lake Pump Station is replaced with a new pump station.

If a new station is built, the design team must work closely with KC operations and maintenance staff to avoid the major operating constraint of the current station. During low flow periods, the small size of the wet well and range of operation of the pumps cause the pumps to frequency cycle on and off. This problem could be minimized by incorporating storage in the influent portion of the Boeing Creek Trunk, and choosing pumps that can operate slowly enough to continuously pump dry weather low flows. The existing overflow/relief sewer orientation would also have to be changed. Currently, the wet well influent from Shoreline Pump Stations No. 4 and No. 5 also forms the wet well overflow (see Figure 6). Backflow into this line would have to be eliminated by either reorienting the piping or installing an appropriate valve. A new pump station overflow/relief sewer could be installed in the upstream piping. All local connections were previously removed from the Boeing Creek Trunk, so locating the relief structure upstream of the pump station will not affect service to local customers so long as the overflow piping is large enough to prevent backups beyond manhole B00-49.

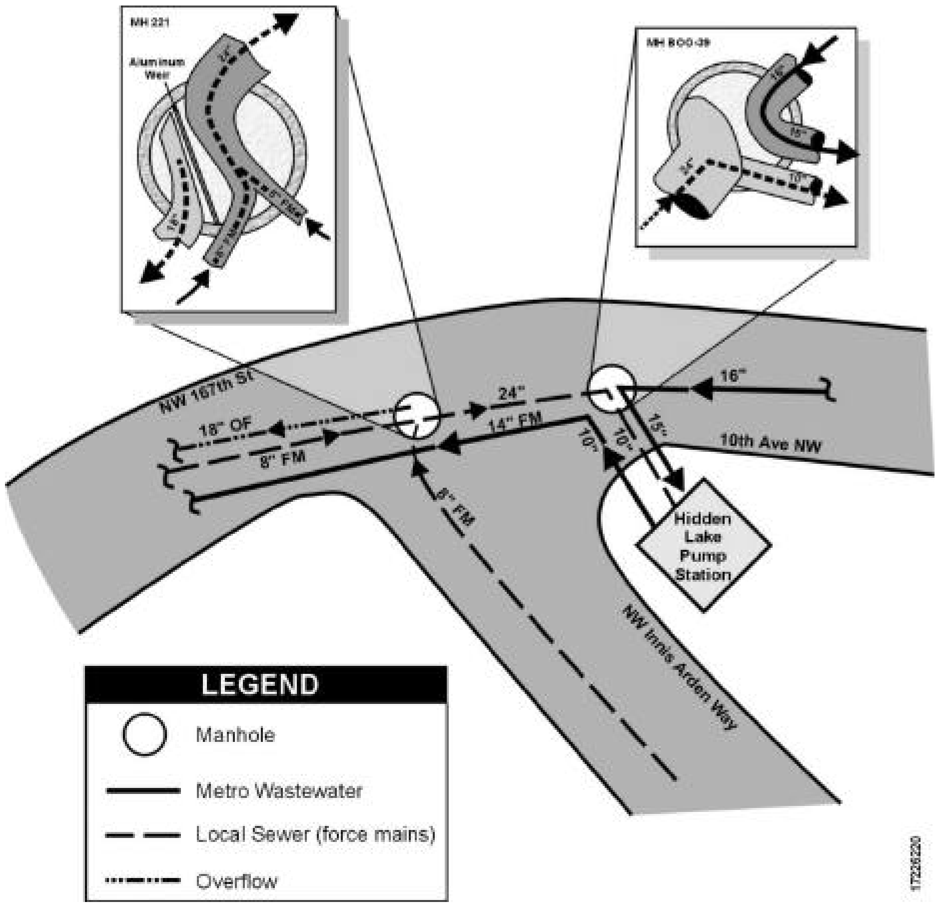


Figure 6. Influent, effluent and overflow piping in the vicinity of the Hidden Lake Pump Station

Figure 7 shows projected peak flows, current and pre-sliplining conveyance capacities along the Boeing Creek Trunk. The paralleling/replacement work is planned for the pipe segments between manholes B00-29 to B00-17 and B00-7 to the Richmond Beach Pump Station (see Figure 8 for replacement/parallel pipe locations). These pipes are shown in Figure 7 as not having enough capacity to pass the 2-year peak flow. Table 12 gives a list of previous and planned pipe rehabilitation work (including paralleling/replacement) for each segment of the Boeing Creek Trunk. Wherever it is feasible, the future rehabilitation work should be superseded by pipe replacement.

It should also be noted that other reaches of the Boeing Creek Trunk (B00-38 to B00-29 and downstream of B00-17) have estimated capacities that are close to the projected 2-year peak flow. Flow data have not been collected in this portion of the trunk (see *Part II: Updated Flow Projections for the Service Area*). The conveyance capacity of the Boeing Creek Trunk should be validated with a dynamic hydraulic model of the pipeline. If the peak flows in this section of the pipeline are higher than previously assumed, either additional pipe will need to be paralleled/replaced, or the level of control will be lower. Replacing additional sections of the trunk will increase costs.

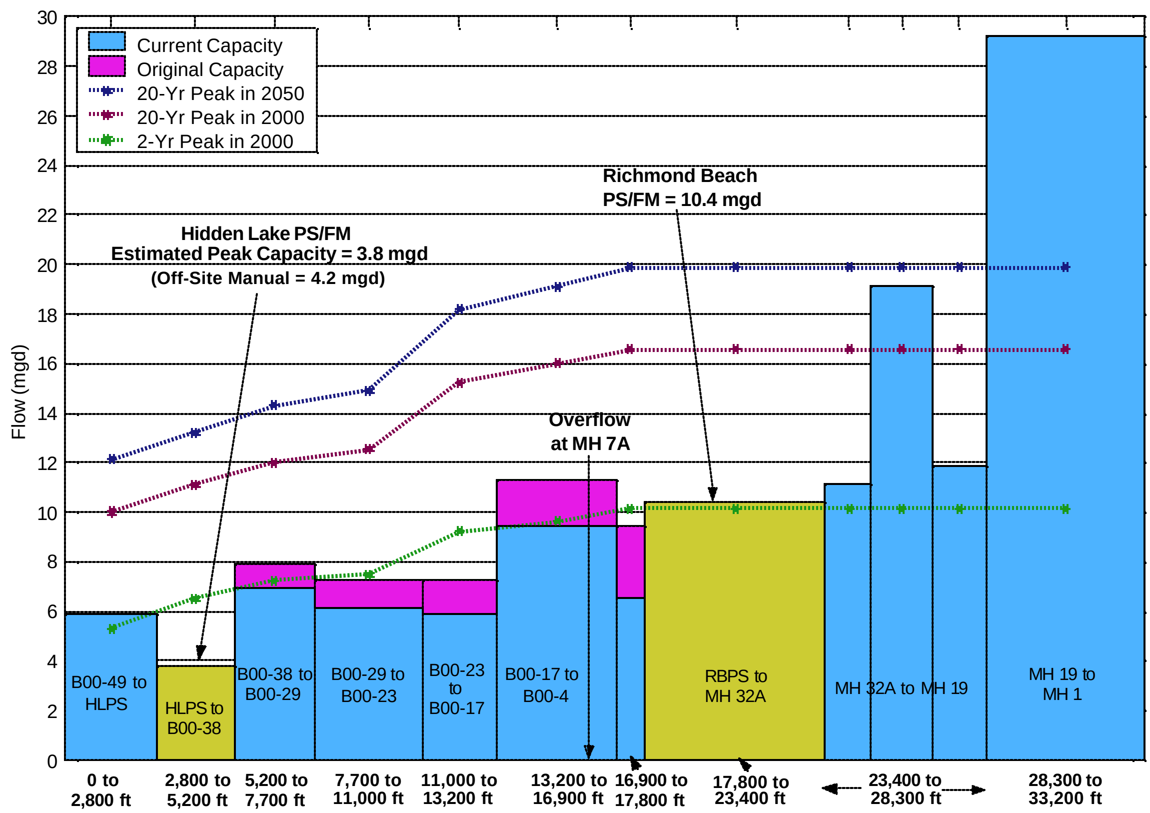


Figure 7. Peak flows and conveyance capacity in the Boeing Creek Trunk.

Table 12. Previous and planned work along the Boeing Creek Trunk

Upstream MH	Down-stream MH	Length (ft)	Diameter (in) [a]	Sliplined in 1988	Planned CIPP Rehab	Planned Parallel/ Replace	No past or planned work
B00-49	B00-48	305	24/15				✓
B00-48	B00-47	341	15				✓
B00-47	B00-46	258	15				✓
B00-46	B00-45	300	15				✓
B00-45	B00-44A	147	15				✓
B00-44A	B00-44	145	15				✓
B00-44	B00-43	246	15				✓
B00-43	B00-42	286	15				✓
B00-42	B00-41	123	15				✓
B00-41	B00-40	235	15				✓
B00-40	B00-39	357	16				✓
B00-39	HL PS	40 (est.)	16				✓
HL PS	B00-38	2375	14				✓
B00-38	B00-37	271	13.1	✓			
B00-37	B00-36A	125	15				✓
B00-36A	B00-36	48	18				✓
B00-36	B00-35	334	13.1	✓			
B00-35	B00-34	439	18				✓
B00-34	B00-33	126	18				✓
B00-33	B00-32A	141	18				✓
B00-32A	B00-32	112	18				✓
B00-32	B00-31	274	18				✓
B00-31	B00-30	327	18				✓
B00-30	B00-29	279	13.1	✓			
B00-29	B00-28	1820	8,16			✓	
B00-28	B00-27	233	15	✓		✓	
B00-27	B00-26	265	15	✓		✓	
B00-26	B00-25	333	13.1	✓		✓	

a. For the pipe sections that were sliplined in 1988, the inner diameter of the HDPE lining is given.

Table 12. Previous and planned work along the Boeing Creek Trunk (cont.)

Upstream MH	Down-stream MH	Length (ft)	Diameter (in) [a]	Sliplined in 1988	Planned CIPP Rehab	Planned Parallel/ Replace	No past or planned work
B00-25	B00-24	344	15	✓		✓	
B00-24	B00-23	319	13.1	✓		✓	
B00-23	B00-22A	15	15	✓		✓	
B00-22A	B00-22	382	15	✓		✓	
B00-22	B00-21	334	15	✓		✓	
B00-21	B00-20	407	18			✓	
B00-20	B00-19	132	18			✓	
B00-19	B00-18A	59	18			✓	
B00-18A	B00-18	175	18			✓	
B00-18	B00-17A	312	20.6	✓		✓	
B00-17A	B00-17	44	24			✓	
B00-17	B00-16	297	18				✓
B00-16	B00-15	282	13.1	✓			
B00-15	B00-14	337	15	✓			
B00-14	B00-13	348	15	✓			
B00-13	B00-12	333	15		✓		
B00-12	B00-11	252	13.1	✓			
B00-11	B00-10	427	18		✓	✓	
B00-10	B00-9	288	13.1	✓			
B00-9	B00-8	206	21		✓		
B00-8	B00-7	60	13.1	✓			
B00-7	B00-6	160	13.1	✓		✓	
B00-6	B00-5	280	15		✓	✓	
B00-5	B00-4	399	15		✓	✓	
B00-4	B00-3	337	18.7	✓		✓	
B00-3	B00-2	316	20.6	✓		✓	
B00-2	B00-1	214	20.6	✓		✓	

a. For the pipe sections that were sliplined in 1988, the inner diameter of the HDPE lining is given.

The CSI project team has performed a preliminary analysis of where the 0.5 MG of storage could be located. The relatively small, flat portion of the Hidden Lake Pump Station property would probably not be large enough to contain a 0.5 MG storage tank. If the new pump station is built adjacent to the existing pump station[15], the existing station's dry pit could be converted to storage after the new pump station is online, but this would only accomplish a small fraction of the 0.5 MG needed. One potential location for offline, gravity in/out storage is along NW 175th Street, between 6th and 10th Avenues NW. A storage tank and associated piping could be located on a section of the vacant property on the northwest corner of NW 175th Street and 6th Avenue NW. Alternatively, an 8-foot diameter offline pipe could be installed from B00-49 to B00-42 (Figure 8). This pipe would measure 1,450 feet in length and would contain approximately 0.5 MG of storage volume. These examples are included to illustrate that storage upstream of Hidden Lake is possible. The location and alignment of storage elements must be examined in greater detail during project predesign.

Table 13 shows cost estimates for both phases of the working alternative. The component costs shown for phase I of the project are Brown and Caldwell estimates and include 10 percent for contractor's operations and profit, 10 percent mobilization/demobilization, 30 percent contingency, 8.6 percent sales tax, and 35 percent for design. The phase II costs assume additional facilities are a diversion pump station and sewer sized to provide enough additional capacity to convey the 20-year peak flow (see Appendix C, slides 17-22).

[15] Building the new pump station adjacent to the existing pump station would allow the current station to continue operating during construction.

Table 13. Working Alternative cost estimate

	Cost (millions; ENR Seattle CCI =7,000)
Project Phase I:	
Replace Hidden Lake PS at 5.5 mgd	3.3[a]
Parallel/Replace 6,400 ft of Boeing Creek Trunk (brings control to 2-year level)	4.0[a,b]
Add 0.5 MG of storage upstream of Hidden Lake PS (brings control to 4 to 5-year level)	2.8[a]
Add KC allied costs (assume +50%)	+50%
Phase I Total	**15.1**
Project Phase II:	
Add facilities (brings control to 20-year level; KC allied costs included)[c]	20.5
Total Project Cost:	**35.6**

a. Brown and Caldwell estimates include 10% contractors O&P, 10% mob/demob, 30% contingency, 8.6% sales tax, and 35% for design. These costs assume the Hidden Lake Pump Station is replaced, not retrofitted.

b. Construction costs in the congested area downstream of the Hidden Lake Pump Station have been increased by 50% to reflect the potential difficulties of design and construction in areas with large numbers of buried utilities.

c. Assumes diversion pump station and sewer sized to bring control to 20-year level with no I/I reduction, and a 7% increase in I/I per decade for 3 decades through 2030.

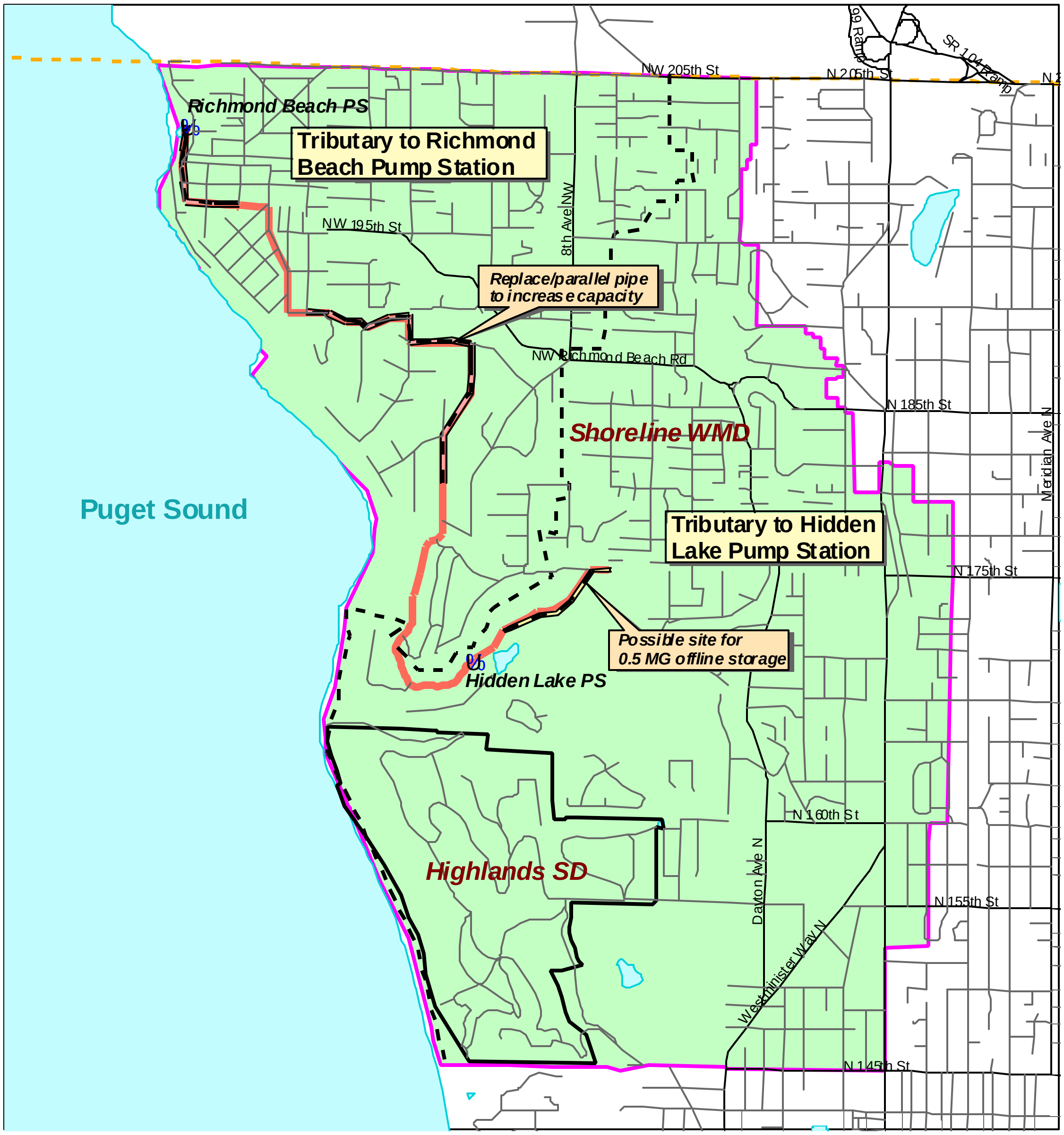


Figure 8: Working Alternative Phase I

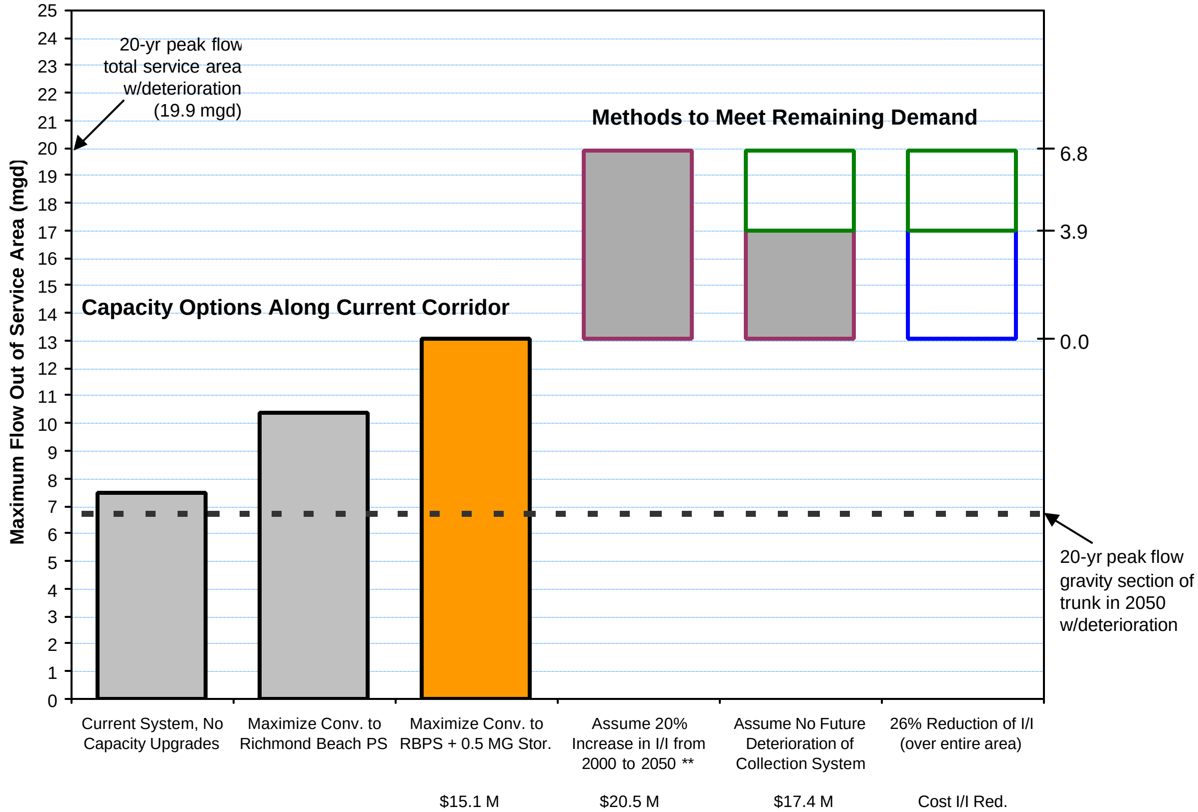
i:\gis\projects\csi project\project\B&C exec summary.apr

Map produced by GIS staff, Wastewater Treatment Division (WTD), King County Department of Natural Resources. WTD disclaims any warranty for use of this digital product beyond that for which it was designed. Neither this digital product, nor any portion thereof may be reproduced in any form or by any means without the expressed written authorization of WTD. This document includes data copyrighted by the Kroll Map Company and is being used with their permission. Use is restricted.

0.1 0 0.1 0.2 0.3 Miles

May 11, 2000

Legend
- Off-line storage pipe
- KC Pump Stations
- Sections to Replace/Parallel
- County Boundary
- Boeing Creek Trunk
- Hidden LK Service Area



** 7 percent per decade I/I increase through 2030

Figure 9. Distribution of costs for interim and future facilities upgrades in the Service Area

APPENDIX A: ENVIRONMENTAL ASSESSMENT OF ALTERNATIVES C AND D3

Alternative C involves intercepting wastewater at manhole B00-49 and pumping northward through a new force main and gravity sewer that intersects the Richmond Beach – Edmonds Interceptor at manhole 32A. Alternative D3 involves constructing a high flow bypass pressure sewer upstream of the Hidden Lake Pump Station that conveys wastewater along the shoreline to the Richmond Beach Pump Station.

The environmental impacts are based on published information in the following documents: the City of Shoreline's *Final Environmental Impact Statement, Volume1, Shoreview Park Capital Project* (1999); the City of Shoreline's *Parks, Open Space, and Recreation Services Plan* (1998); the City of Shoreline's *Draft Environmental Statement, Comprehensive Plan* (1997); King County's *Sensitive Areas Ordinance and Map Folio* (1990), and the *Puget Sound Environmental Atlas* (1987). Detailed field reconnaissance of the pipeline alignment has not been conducted for this report. Field verification would be necessary prior to final design.

Alternative C: Environmental and Construction Impacts and Permitting

<u>Existing Conditions</u>

Natural Environment

Topography and Soils: The Alternative C alignment would pass through one relatively steep slope area at the proposed gravity sewer location between 8th Avenue NW and 104th Avenue W along SW 244th Street. The topography drops approximately 80 feet over a distance of 200 feet, or roughly a 40 percent slope. The remainder of the pipeline alignment is located on a rolling plateau with a gentle north/south topographic orientation. Elevations in the area range from a low of 220 feet above mean sea level (MSL) where the proposed pipeline replacement will run between Algonquin Road and North Deer Road along Woodway Park Road, to a high elevation of 440 feet MSL along 8th Avenue NW.

Soils along the pipeline alignment are reportedly Alderwood series soils (City of Shoreline, 1997). Alderwood soils consist of a gravelly, sandy loam, and tend to have sufficient surface drainage. Everett series soils appear on the slopes leading down to Puget Sound and in the area of Boeing Creek. The Everett soils are similar to Alderwood soils (gravelly, sandy loam), except they are typically found below elevation 500 feet. However, because Everett soils are mostly coarse gravel and sand, they tend to drain rapidly.

Erosion Hazard: Erosion hazards are present within the project area, especially in the area of Boeing Creek. According to the *King County Sensitive Areas Ordinance and*

Map Folio (1990), an erosion hazard exists on the new pipeline route on the steep slopes along the SW 244th Street portion of the alignment (see Task 230, Figure 1). Additionally, the route from NW 180th Street to the Hidden Lake Pump Station is considered an erosion hazard area (King County, 1990).

Landslide Hazards: The only mapped landslide area within the study area lies north of the existing Hidden Lake Pump Station, along 10th Avenue NW (the Boeing Creek corridor) to N 175th Street. These areas are on a lower elevation compared to the adjacent bluffs along the Boeing Creek ravine.

Seismic Hazards: The pipeline alignment does not cross any mapped seismic hazard areas.

Hazardous Materials: Based upon documentary information (e.g., King County records), there is no evidence of significant quantities of hazardous materials within the project area. Some businesses in the project area, such as service stations, manufacturers, paint supply stores, etc., likely use and store hazardous materials. Because the majority of the pipeline route is through residential areas and because the area has historically been residential, the likelihood of encountering significant quantities of existing or historical hazardous materials is low.

Significant Vegetation: The City of Shoreline has identified significant areas of primary and secondary types of vegetation within the vicinity of the project alignment. Primary areas are areas of vegetation with little or no development that tend to occur in ravines, steep slopes, native growth easements, natural reserves, and parks. More widespread areas of secondary vegetation cover residential areas and large lots, with interspersed large tree stands. Existing mature vegetation is an important characteristic of the Richmond Beach/Innis Arden area.

The only designated significant areas of vegetation near the project alignment exist at Boeing Creek Park and adjoining Shoreview Park (City of Shoreline, 1998). However, the Alternative C alignment would not likely alter areas with designated significant vegetation. The proposed pipeline would pass entirely along roadway rights-of-way, except for a small portion of open space in southwest Snohomish County.

Water Features:

Surface Water Basins: The Alternative C alignment would lie within two surface drainage basins in King County. These basins include the Middle Puget Sound Basin (North) and the Boeing Creek Basin. Runoff generated along the proposed alignment in the Boeing Creek Basin flows either directly into Boeing Creek or Puget Sound. Runoff generated in the Middle Puget Sound Basin (North) discharges directly into Puget Sound.

Streams and Creeks: Boeing Creek, listed as a Class 2 stream, and its associated wetlands are the only surface waters near the proposed alignment, according to the *King County Wetland Inventory* (1991). The force main alignment would be located approximately 250 feet from Boeing Creek along 10th Avenue NW. Over the past 30 years, the area of the creek previously referred to as Hidden Lake, filled with silt and developed into a forested wetland. The King County Surface Water Management Division modified Hidden Lake, creating an open water wetland in 1998. The highly urbanized and relatively impervious nature of the Boeing Creek watershed has affected the water quantity and quality of the stream. High flow fluctuations have resulted in streambed scouring, stream bank erosion, and sediment deposition. Over the years, urbanization has increased the release of sediments and chemicals into Boeing Creek, thus degrading the habitat value.

Marine Shoreline: The only marine shoreline in proximity of the project area lies on the shore of Puget Sound. The *King County Map Folio* (1990) lists the entire shoreline as Class 1. Therefore it is listed and inventoried as a “Shoreline of the State” under the King County Shoreline Master Program and has a 100-foot shoreline buffer requirement. The Alternative C route would remain outside the 100-foot buffer zone established by King County.

Flood Hazard Areas: The proposed alignment route contains approximately 37 acres considered to be flood hazard areas, which are located in the Boeing Creek corridor. The proposed force main route along 10th Avenue NW lies within a 100-year floodplain (King County, 1990).

Wetlands: The only mapped wetland in the vicinity of the Alternative C alignment is the 2-acre Boeing Creek wetland, located approximately 250 feet from the proposed pipeline between the intersection of 10th Avenue SW and Innis Arden Way. This encompasses an area adjacent to the southwest corner of Shoreview Park. This wetland was significantly affected by a mudslide in 1997.

<u>Construction Impacts</u>

Traffic Impacts

Various arterials and streets would be affected by the construction of the proposed Alternative C pipeline. Local streets include 16th Avenue W, NW 167th Street, 10th Avenue NW and NW 185th Street. Collector arterials include NW 175th Street, 6th Avenue NW, 8th Avenue NW (from NW 185th Street to Richmond Beach Road), and Timber Lane. Minor arterials in the project area include 8th Avenue NW (north of Richmond Beach Road) and the Alternative C proposed alignment replacement sections of Woodway Park Road. The residential streets that would be affected include 104th Avenue W, 238th Street SW, and 239th Place SW.

Transit routes #304, #315, and #301 provide service from the City of Shoreline to downtown Seattle. Transit Routes #304 and #315 run along Richmond Beach Road and cross 8th Avenue NW. Transit Route # 301 travels along 8th Avenue NW from Richmond Beach Road north to the King/Snohomish County Line. The following three bus stops along this route would be temporarily altered by the proposed alignment: the stop between NW 205th Street and NW 197th Street, the stop near NW 193rd Street, and the stop near NW 190th Street.

The City of Shoreline's general policy regarding construction in roadways is to avoid road closures on designated arterials. The road closure policy on non-arterials is that signs and newspaper ads are required at least five days prior to the construction date.

Table A1 summarizes the roadways within the study area potentially affected by the Alternative C route.

Table A1. Roadways affected by the Alternative C proposed alignment.

Street Name	Type of Street	Speed Limit	Street Width (ft)	Potential Issues
16th Ave. West	Local Street	20	60	-Homes vary in distance from road, some are within 100 ft. -Many driveways have access to the road.
NW 167th St.	Local Street	20	60	-Residences vary in distance from road, some homes are within 100 feet of the road and visually unprotected from construction activities with no fences or large bushes.
10th Ave. NW	Local Street	25	60-40	-Large drop off to the south west of road. -Minimal shoulder width on both sides of the road. -The road becomes narrows to 40 ft. travelling toward Innis Arden Way, with a bridge ~250 ft. long that was recently retrofitted for earthquake protection by King County.
NW 175th St.	Collector Arterial	35	60	
6th Ave. NW	Collector Arterial	25	60-50	-The road at the intersection of NW 178th Pl. narrows to 50 ft. across.
NW 185th St.	Local Street	25	60	
8th Ave. NW	Collector Arterial (NW 175th St. to NW 180th St.) Minor Arterial (NW 180th St. to 205th St.)	35	60	-From NW 195th Street to the County Line, a drainage ditch lies to the east ~8 ft. from the edge line. -West of the road, homes reach as close as 20 ft. from the street boundary. -There is no paved sidewalk on either side of the road.
104th Ave. W	Residential Street	25	60-45	-Road narrows to 45 ft. for approximately 200 ft. along the road over a hump.
239th Pl. SW	Residential Street	25	60	-Alignment would run through residential neighborhood with homes set back over 100 ft. however, they all have driveways leading to the road.
Timber Lane	Minor Collector Arterial	25	60	-5 residences on the east side of the road are within 50-100 ft. of the road, with driveways leading to the right-of-way. -No shoulder on the west side.
238th St. SW	Residential Street	25	60	
Woodway Park Road	Minor Collector Arterial	25	60	

Within the City of Shoreline, local impacts to five streets would have to be taken into consideration with the implementation of the Alternative C alignment. Residences along 16^{th} Avenue W, NW 167^{th} Street, and 8^{th} Avenue NW have homes that exist within 100 feet of the road. These adjacent properties also utilize driveways that have direct access to the impacted roads. Two streets along the proposed route contain sections where the roadway narrows. At the intersection of 6^{th} Avenue NW and NW 178^{th} Place, the road narrows to 50 feet. Along the 10^{th} Avenue NW route, there exists a 250-foot bridge (approximately 50 feet wide) near the Innis Arden Way intersection. The proposed pipeline would either have to be channeled directly into the cliff, northwest of the bridge or be suspended underneath the bridge. Either possibility must consider the open water wetland to the southeast of 10^{th} Avenue NW.

In the Town of Woodway, properties adjacent to Timber Lane have homes within 100 feet of the road. Furthermore, driveways would be impacted along 239^{th} Place SW and Timber Lane that have access to the proposed pipeline route. Finally, a section of road along 104^{th} Avenue W narrows to 45 feet in width near the King/Snohomish County Line.

Air

Construction of the conveyance pipeline would not be a major source of air quality degradation. The excavation phases would generate small quantities of particulate matter (fugitive dust). A majority of the proposed alignment runs along road rights-of-way surrounded on both sides by low-density residential homes (with the exception of commercial businesses that exist on a two-block portion of 8^{th} Avenue NW, from NW 185^{th} Street to NW 189^{th} Street). Construction vehicles and heavy equipment would generate localized and temporary gasoline and diesel exhaust fumes, and dust on roadways, affecting the residences along the proposed pipeline corridor for a period of days.

Noise

Currently, traffic is the major source of noise to residents who live within the project area. On a short-term basis, residents along the project alignment would be impacted by noise from heavy construction equipment. This increase would generally occur during daytime working hours. Noise impacts would be most noticeable to those receptors closest to the construction area and along roadways used for construction vehicles. The proposed alignment route occurs in roadway rights-of-way adjacent to high and low-density residents (with the exception of commercial businesses that exist on a two-block portion of 8^{th} Avenue NW, from NW 185^{th} Street to NW 189^{th} Street).

Noise levels could reach as high as 90 decibels (dBA) for short periods of time within 50 feet from the noise source. This would directly affect those residents living along 16^{th} Avenue W, NW 167^{th} Street, 8^{th} Avenue NW, and Timber Lane. Noise associated with clearing and excavation typically falls within the 84 to 88 dBA range. Trucks used to haul excavated fill would also temporarily increase noise along haul routes. Construction-related noise impacts would be localized and short-term.

Utilities

Most of the arterials where the construction would occur contain underground and aboveground utilities, including power, water, cable, phone, and natural gas. Coordination with local utility companies within the project area would be essential to ensure safe working conditions and minimize disruptions to service.

Permits

Table A2 lists permits that would be required to construct the Alternative C proposal.

Table A2. Alternative C permitting requirements

Jurisdiction	Permit	Trigger/Activity
City of Shoreline	Right-of-Way Use Permit	-Necessary for construction in city roadways. -The permit provides and requires a detailed checklist of permitting needs for the City of Shoreline including: a City of Shoreline Permit Application Form, Proof of License, Bonding and Insurance, Traffic Control Plan, a Site Plan, an Erosion and Sedimentation Control Plan, and other documentation the City may request.
	Sensitive Areas Review	-Construction in steep slope hazard area.

To perform construction in the City's right-of-way easements, the contractor must fulfill the requirements of the local right-of-way use permit. The permit requires completion of a detailed checklist of permitting needs for the City of Shoreline.

Shoreline requires a full-width overlay for all surface street restoration work. The contractor will typically be required to go a little beyond the jagged edge pavement cut near the trench for restoration. Various trenchless construction technologies are allowed and encouraged because they limit interference with traffic flow and can potentially reduce restoration costs. Construction of the new sanitary sewer along unpaved shoulders may be allowed, depending upon availability of space. Shoreline has no restrictions on allowable pipe materials.

Summary of Impacts and Permitting Requirements for Alternative C

The potentially most significant natural environment constraints to the Alternative C project would be construction along the Boeing Creek corridor along 10th Avenue NW due to the sensitive characteristics of the area. Best Management Practices (BMPs) would have to be incorporated into the construction plans near this area of the project to ensure no adverse impacts will occur to the natural habitat. These would include development of erosion and sediment control plans, sensitive areas review, less invasive construction methodologies, and restoration immediately after construction.

The most significant local construction impacts relate to traffic. Streets that will require the most coordination with local officials in the City of Shoreline are 16th Avenue W, NW 167th Street, 10th Avenue NW, 6th Avenue NW, and 8th Avenue NW. The Town of Woodway officials would be concerned with construction along 104th Avenue W, 239th Place SW, and Timber Lane.

Alternative D3: Environmental and Construction Impacts and Permitting

Existing Conditions

Natural Environment

Topography and Soil: The Alternative D3 alignment would pass through one relatively steep slope area just east of 16th Avenue NW, where the sewer pipeline runs east toward the beach. The slope in the area is approximately 180 feet over a distance of 500 feet, or roughly a 35 percent slope. The remainder of the pipeline alignment is located on a rolling plateau with a gentle north/south topographic orientation from the intersection of NW 175th Street and 10th Avenue NW to the end of 16th Avenue NW. Elevations in the area range from approximately sea level to a high of approximately 340 feet MSL along the 10th Avenue NW portion of the pipeline route.

Soils along the pipeline alignment are reportedly Alderwood series soils (City of Shoreline, 1997). Alderwood soils consist of a gravelly, sandy loam, and tend to have sufficient surface drainage. Everett series soils appear on the slopes leading down to Puget Sound and in the area of Boeing Creek. The Everett soils are similar to Alderwood soils (gravelly, sandy loam), except they are typically found below elevation 500 feet. However, because Everett soils are mostly coarse gravel and sand, they tend to drain rapidly.

Erosion Hazard: According to the *King County Sensitive Areas Ordinance and Map Folio* (1990), the only known erosion hazard exists from NW 175th Street to the Hidden Lake Pump Station (see Task 230, Figure 1).

Landslide Hazards: Landslide hazards are significant along the Alternative D3 alignment. A major portion of the proposed beach route, which parallels the BNSF railroad up to the intersection at Richmond Beach Drive NW and NW 194th Street, is considered a landslide hazard area (King County, 1990).

Seismic Hazards: Approximately 1.5 miles of the pipeline route along the Puget Sound shoreline is mapped as a seismic hazard area (King County, 1990).

Hazardous Materials: The *Puget Sound Environmental Atlas* (1987) has documented evidence of the following chemicals in the vicinity of the proposed pipeline alignment in Puget Sound: low molecular weight polycyclic aromatic hydrocarbons, high molecular weight polycyclic aromatic hydrocarbons, PCB’s, arsenic, cadmium, copper, mercury, lead and zinc. Although these potential contaminants have been measured in the project area, further studies must be performed to determine the precise location and amounts of the materials along the pipeline alignment. Testing would be necessary to determine that sediments disturbed by construction would not adversely impact construction workers or the marine environment.

Significant Vegetation: The City of Shoreline has identified significant areas of primary and secondary types of vegetation within the vicinity of the project alignment. Primary areas are areas of vegetation with little or no development that tend to occur in ravines, steep slopes, native growth easements, natural reserves, and parks. More widespread areas of secondary vegetation cover residential areas and large lots, with interspersed large tree stands. Existing mature vegetation is an important characteristic of the Richmond Beach/Innis Arden area.

The only designated significant areas of vegetation near the project alignment exist at Boeing Creek Park and adjoining Shoreview Park (City of Shoreline, 1998). However, the Alternative D3 alignment would not likely alter areas with designated significant vegetation. The proposed pipeline would pass entirely along roadway rights-of-way, except for a small portion of open space in southwest Snohomish County.

Water Features

Surface Water Basins: The Alternative D3 alignment would lie within two surface drainage basins in King County. These basins include the Middle Puget Sound Basin (North) and the Boeing Creek Basin. Surface water in the project vicinity flows into either Boeing Creek or directly into Puget Sound.

Streams and Creeks: Boeing Creek, listed as a Class 2 stream, and its associated wetlands are the only surface waters near the proposed alignment according to the *King County Wetland Inventory* (1991). The force main alignment would be located approximately 250 feet from Boeing Creek along 10th Avenue NW. Over the past 30 years, the area of the creek previously referred to as Hidden Lake, filled with silt and developed into a forested wetland. The King County Surface Water Management Division modified Hidden Lake creating an open water wetland in 1998. The highly urbanized and relatively impervious nature of the Boeing Creek watershed has affected the water quantity and quality of the stream. High flow fluctuations have resulted in streambed scouring, streambank erosion, and sediment deposition. Over the years, urbanization has increased the release of sediments and chemicals into Boeing Creek, thus degrading the habitat value.

Marine Shoreline: The primary marine shoreline that would be affected by the Alternative D3 alignment would be the large estuarine system (mixture of salt and fresh water) of Puget Sound. The *King County Map Folio* (1990) lists the entire shoreline as Class 1, therefore, it is listed and inventoried as a “Shoreline of the State” under the King County Shoreline Master Program and has a 100-foot buffer requirement. Furthermore, Puget Sound provides habitat for the Chinook salmon (listed as “endangered” by the federal government under the Endangered Species Act) and the coho salmon. The Alternative D3 alignment would infringe upon the shoreline and the standard buffer.

According to the *Puget Sound Environmental Atlas* (1987) the proposed alignment passes through a significant amount of eelgrass beds in Puget Sound. Eelgrass beds are important for a number of species residing in Puget Sound. Large numbers of invertebrate species live either in the organic-rich sediments trapped by eelgrass, on eelgrass blades. Birds, a low tide, and fish such as salmon and flatfish forage in eelgrass beds.

Construction of the proposed pipeline route would impact the shoreline, which is mapped as a shellfish resource for Dungeness crab. In addition, this Puget Sound shoreline area is designated as a tribal usual and accustomed fishing place for the Muckleshoot, Suquamish, and Tulalip Tribes (*Puget Sound Environmental Atlas*, 1987).

<u>Flood Hazard Areas</u>: According to the *King County Sensitive Areas Ordinance and Map Folio* (1990), the proposed alignment would remain outside mapped flood plains. The Hidden Lake Pump Station is located in a 100-year floodplain. However, the diversion pump station would be constructed approximately 250 feet from the floodplain.

<u>Wetlands</u>: The only mapped wetland in the vicinity of the Alternative D3 alignment is the 2-acre Boeing Creek wetland, located approximately 250 feet from the proposed pipeline between the intersection of 10th Avenue SW and Innis Arden Way. This encompasses an area adjacent to the southwest corner of Shoreview Park. This wetland was significantly affected by a mudslide in 1997.

<u>Construction Impacts</u>

Marine Impacts

As mentioned above, numerous impacts to the shoreline of Puget Sound would have to be addressed with the implementation of the Alternative D3 alignment. Impacts to the Puget Sound wildlife, vegetation, and tribal agreements would have to be taken into consideration with the development of a plan for the Alternative D3 proposed alignment.

If the pipeline were installed in Puget Sound, there would be no appropriate way to flush accumulated solids from the flat portion of the pipeline constructed near the beach. It is possible that this pipeline section would produce noticeable odors on the beach during the summer months.

Traffic Impacts

Construction of the Alternative D3 route would only impact a few roads. Construction would affect the local streets of 10th Avenue NW (from NW 175th Street to NW Innis Arden Way), NW 167th Street (from Innis Arden Way to 15th Avenue NW), and 16th Avenue NW (from 15th Avenue NW to the road's dead end).

Table A3 summarizes the roadways within the study area potentially affected by the Alternative D3 route:

Table A3. Roadways affected by the Alternative D3 proposed alignment.

Street Name	Type of Street	Speed Limit	Street Width (ft)	Potential Issues
16th Ave. West	Local Street	20	60	-Homes vary in distance from road, some are within 100 ft. -Many driveways have access to the road.
NW 167th St.	Local Street	20	60	-Residences vary in distance from road, some homes are within 100 feet of the road and visually unprotected from construction activities with no fences or large bushes.
10th Ave. NW	Local Street	25	60-40	-Large drop off to the south west of road. -Minimal shoulder width on both sides of the road. -The road narrows to 40 ft. travelling toward Innis Arden Way, with a bridge ~250 ft. long that was recently retrofitted for earthquake protection by King County.

Construction planning along the Alternative D3 alignment must consider impacts to three roads. Some residences along 16th Avenue W and NW 167th Street lie within 100 feet of the road. These adjacent properties also utilize driveways that have direct access to the impacted roads. A 250 foot-long bridge (approximately 50 feet wide) is located along 10th Avenue NW, near the Innis Arden Way intersection. The proposed pipeline would either have to be constructed into the cliff, parallel to the bridge or be suspended beneath the bridge. The open water wetland to the southeast of 10th Avenue NW would have to be considered.

Air

Construction of the conveyance system pipeline would not be a major source of air quality degradation. The excavation phases would generate small quantities of particulate matter (fugitive dust). A majority of the proposed alignment runs along the Puget Sound shoreline, except along the road rights-of-way where low-density residential homes exist. The impacts of the dust would be localized and temporary, affecting the residences that align the proposed pipeline corridor for a period of days (depending upon construction plans at each section of the pipeline). Construction vehicles and heavy equipment would generate gasoline and diesel exhaust fumes and dust on roadways. These impacts would be localized and short-term.

Noise

Currently, the major sources of noise affecting residents and visitors to the project area include traffic, trains along the Burlington Northern Santa Fe (BNSF) railroad, and the waves from Puget Sound. On a short-term basis, noise from heavy construction equipment would be generated at construction sites along the project alignment. Noise levels could reach as high as 90 decibels (dBA) for short periods of time within 50 feet from the noise source. This would directly impact those residents living along 16th Avenue NW and 167th Street NW. Noise associated with clearing and excavation typically falls within the 84 to 88 dBA range. Trucks used to haul excavated fill would also temporarily increase noise along haul routes. Construction-related noise impacts would be localized and short-term. In addition, construction activities would be limited to daytime hours.

Utilities

Most of the arterials where the construction would occur contain underground and aboveground utilities, including power, water, cable, phone, and natural gas. Coordination with local utility companies within the project area would be essential to ensure safe working conditions and minimize disruptions to service.

No utilities are known to exist along the shoreline of Puget Sound.

Permits

Table A4 below lists permits or reviews that may be required in order to construct Alternative D3.

To perform construction in the City's right-of-way easements, the contractor must fulfill the requirements of the local right-of-way use permit. The permit requires completion of a detailed checklist of permitting needs for the City of Shoreline.

Shoreline requires a full-width overlay for all surface street restoration work. The contractor will typically be required to go a little beyond the jagged edge pavement cut near the trench for restoration. Various trenchless construction technologies are allowed and encouraged because they limit interference with traffic flow and can potentially reduce restoration costs. Construction of the new sanitary sewer along unpaved shoulders may be allowed, depending upon availability of space. Shoreline has no restrictions on allowable pipe materials.

Table A4. Alternative D3 permitting requirements

Jurisdiction	Environmental Review/ Permit	Trigger/Activity
US Army Corps of Engineers	Individual 404	-Discharge of dredged and fill material into a waterway
	Section 10	-Any work in or affecting navigable waters of U.S. (e.g., piers, floats, outfalls, dredging, etc.)
	Biological Assessment[a]	-Any work done in potential Endangered/ Threatened species habitat.
Washington State	State Environmental Policy Act (SEPA) review	-Process is integrated with activities to ensure that planning and decisions reflect environmental values and seeks to resolve potential problems.
WA State Department of Ecology	Coastal Zone Management Consistency (CZM)	-Required for Corps authorized projects. -Ecology reviews for CZM consistency
	Water Quality Certification (WQC)	-Federal permits to conduct any activity that may result in a discharge of dredge or fill material into water or wetlands
WA State Dept. of Fish & Wildlife	Hydraulic Project Approval (HPA)	-Work that uses, diverts, obstructs, or changes the natural flow or bed of state waters
Burlington Northern Santa Fe Railroad	Utility License Agreement	-Work that will occur within the BNSF right-of-way
City of Shoreline	Right-of-Way Use Permit	-Necessary for construction in city roadways. -The permit provides and requires a detailed checklist of permitting needs for the City of Shoreline including: a City of Shoreline Permit Application Form, Proof of License, Bonding and Insurance, a Traffic Control Plan, a Site Plan, an Erosion and Sedimentation Control Plan, and other documentation the City may request.
	Sensitive Areas Review	-Construction in steep slope hazard area, along shoreline.
	Shoreline Conditional Use	-Construction in a shoreline area.

[a:] Washington State agencies would also require a biological assessment.

Summary of Impacts and Permitting Requirements for Alternative D3

The most significant natural environment constraints to the construction of the Alternative D3 alignment would be construction in Puget Sound and along the Boeing Creek corridor. Construction along Puget Sound would require significant environmental analyses and permitting. A biological assessment would be necessary for compliance with the Endangered Species Act. To implement the Alternative D3 alignment, extensive coordination with permitting agencies and BNSF would have to be performed, and significant mitigation measures would likely be required. Furthermore, coordination with local officials from the City of Shoreline would be necessary to address the impacts to 16th Avenue NW, NW 167th Street, 10th Avenue NW, and 10th Avenue NW.

King County personnel asked the CSI project team to investigate if there would be cost and permitting benefits with construction timed to coincide with Sound Transit track work in the area. Discussions with Sound Transit personnel revealed that there are already two railroad tracks at the bottom on the bluffs at the west edge of the Service Area. Sound Transit does not plan on adding an additional track in the Service Area. (Additional track will be laid in Snohomish County where there is only one rail line.) Therefore, there would not be an opportunity for coincident construction, and the responsibility for obtaining all the necessary permits mentioned above would be shouldered by KC WTD.

APPENDIX B: SUMMARY OF HIDDEN LAKE DECISION WORKSHOP

MEMORANDUM

TO: Bob Peterson – King County
Jim Peterson – HDR

FROM: Lori Jones – Brown and Caldwell
Tony Dubin – Brown and Caldwell

SUBJECT: Summary of Hidden Lake Decision Workshop – March 16, 2000

On March 16, 2000, the CSI project team met with several King County staff at the King Street Center to discuss the progress to date on Conveyance System Improvement planning for the Hidden Lake – Richmond Beach service area (see Appendix B.1 for attendees list; Appendix C for the presentation slides). The objective of the workshop was to reach a consensus on a program that would meet the immediate upgrade needs at the Hidden Lake Pump Station, reduce the number of sanitary overflows in the service area, and achieve the RWSP 20-year control level. The workshop began with Jack Warburton of BC describing the current conveyance problems in the service area. These include:

- The Hidden Lake Pump Station wet well and the weir at Boeing Creek Trunk manhole 7A each overflow approximately 3 to 5 times per year[16]. Some of these discharges result in untreated discharges to Puget Sound.
- The Boeing Creek Trunk manholes B00-2, B00-3, B00-4, B00-7, B00-8 and B00-9 have experienced surcharging; manholes B00-22 and B00-29 have overflowed. (See Appendix C, slide 3)
- The Hidden Lake Pump Station has documented operational problems. The station is almost 40 years old and requires substantial electrical, instrumentation and mechanical updates. A critical issue is that the current wet well has very little capacity to manage current 20-year peak flows.
- The limited capacity of the Boeing Creek Trunk has resulted in backups into local sewers. Previous sliplining reduced conveyance capacity along sections of the pipeline, and Shoreline WMD links the sliplining to some of the problems experienced by their customers.

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[16] This estimate includes both storm-related overflows and mechanical failures resulting in overflows.

- Capacity restrictions along the Boeing Creek Trunk prevent the full capacity of the Richmond Beach Pump Station from being used. Even when overflows are occurring upstream, the peak flow at Richmond Beach typically ranges from 7 to 7.5 mgd. The station has a peak capacity of 10.4 mgd.

The discussion of current configuration and identified problems was followed by a summary of the service area flow projections relative to the capacity of the existing facilities. The projected 20-year peak flow is higher than the capacity of all King County facilities tributary to Richmond Beach (see Appendix C, slide 7). It was noted that peak flows in the service area are composed largely of I/I (see Appendix C, slide 8). Approximately 88 percent of the projected peak flow of 19.9 mgd in 2050 (assuming 7% per decade increase in I/I for 3 decades) would be due to I/I. The population and employment growth rate in the service area is small; planning for future wastewater needs is driven largely by I/I concerns. There was some discussion about the impacts of sewer deterioration on I/I rates. Gunars Sreibers and Marcos Lopez both noted that minimizing the effect of sewer aging on I/I rates is a goal of the I/I program.

After reviewing the system alternatives that were developed in earlier CSI work, some additional alternatives emerged by combining the following elements:

- Increasing the conveyance capacity along the current corridor
- Incorporating storage to attenuate peak flows
- Managing demand by reducing I/I or reducing the amount of sewer deterioration
- Constructing a pump station and diversion sewer to carry peak flows away from the Boeing Creek Trunk

In all alternatives, it was assumed that reconstructing the Hidden Lake Pump Station is a high priority and would occur at the beginning of the program. In other cases, it was assumed some of the work would be performed immediately and the rest would coincide with the results of the North Plant siting project and the Regional I/I study.

Two promising Hidden Lake system scenarios were presented (see Appendix C, slide 22):

A. Rebuild Hidden Lake Pump Station immediately, make spot improvements to Boeing Creek Trunk, and monitor and respond to overflows. When the results of the I/I program become available (assumed 2005), construct a diversion pump station and pipeline large enough to meet the RSWP standard of one overflow per 20 years; or,

B. Rebuild Hidden Lake Pump Station at 5.5 mgd, and expand capacity along sections of the Boeing Creek Trunk in order to utilize full capacity of the Richmond Beach Pump Station, providing conveyance for the 2-year peak flow. One half million gallons (0.5 MG) of storage could be added upstream to increase the control level to the 4 or 5-year peak flow. When the results of the I/I program are available, control could be brought to the 20-year level through a combination of additional storage and I/I reduction, or other facility improvements.

Christie True suggested that option B would provide immediate relieve for local customers, demonstrate the County's strong desire to reduce overflows and allow time for the Regional I/I program to work. She felt the benefits of reducing the number of overflows quickly more than outweighed the estimated 10 to 15 percent additional cost of option B. Mike Fischer stated that overflows are unacceptable and every effort should be made to limit overflows immediately, and as such was in favor of option B. Shirley Marroquin described possible ESA and HCP concerns related to overflows and stated that KC would be sending the wrong message with a program that would not reduce the number of overflows until several years into the future. Shirley also acknowledged that option A would demonstrate a *business-as-usual approach* by accepting and conveying all flows from the local agency while running counter to the goals of the Regional I/I program; this was echoed by others. Roger Browne also expressed his preference for option B.

In conclusion, there was a strong consensus that option B would be the best course of action. The attendees felt this option would provide the best balance of immediate SSO reduction, coordination with the Regional I/I and North Plant siting projects, and limiting capital and O&M costs. It was also acknowledged that King County, particularly through the Regional I/I program, should make data collection within the service area a priority, specifically in the area downstream of the Hidden Lake Pump Station, which drains to the gravity portion of the Boeing Creek Trunk. Additional monitoring within the service area coupled with improved 20-year peak flow projections should be completed prior to final facilities design.

Action Item:

The Hidden Lake CSI project team will complete the final draft of the Hidden Lake Task 250 report incorporating direction from the workshop. This report will also include a more detailed description of the addition of storage upstream of the Hidden Lake Pump Station to help alleviate the problem due to the under capacity of the wet well and, based on the workshop discussion, will identify specific elements to be investigated during predesign. The final Task 250 report and the summary Task 260 will be included with the pending formal transfer of this project to the CIP program.

APPENDIX B.1. DECISION WORKSHOP ATTENDANCE LIST

CSI Hidden Lake – Richmond Beach Basin Decision Workshop

Thursday March 16, 2000 at 10:00 a.m. on the 8th Floor of the King County building

Meeting Attendees:

Bob Peterson – King County

Katherine McKee – King County

Ed Cox – King County

Bob Swarner – King County

Mark Lampard – King County

Roger Browne– King County

Marcos Lopez– King County

Dave Dittmar – King County

Calvin Locke – King County

Mike Fischer – King County

Gunars Sreibers – King County

Christie True – King County

Shirley Marroquin – King County

John Vaughn – King County

Peter Keum – King County

Dick Finger – King County

Jim Peterson – HDR

Sam Perry - HDR

Jack Warburton – Brown and Caldwell

Tony Dubin – Brown and Caldwell

Lori Jones – Brown and Caldwell

APPENDIX C: DECISION WORKSHOP PRESENTATION SLIDES

King County Conveyance System Improvement Project

Task 260

Hidden Lake Service Area Task Summary Report

Hidden Lake Service Area
Task 260: Task Summary Report

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KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT
HIDDEN LAKE SERVICE AREA TASK SUMMARY

This Task 260 report summarizes the Conveyance System Improvement (CSI) Project team's work in the Hidden Lake Service Area[1] (Service Area) and outlines recommended alternatives for addressing wastewater conveyance issues in the Service Area. Specifically, this report describes the Hidden Lake Service Area and summarizes its planning history. The report then describes the wastewater facilities that presently serve the area, and identifies existing capacity limitations and mechanical problems. The report then summarizes the alternatives developed and analyzed to identify a working alternative for relieving capacity and mechanical problems. Constraints to capacity improvements posed by the area's natural and physical environment are also noted.

TASK 210: HIDDEN LAKE SERVICE AREA PLANNING HISTORY

The Hidden Lake Service Area is located in northwest King County in the City of Shoreline (Figure 1). The Service Area includes areas draining to the Hidden Lake Pump Station and all areas contributing to wastewater flows in the King County conveyance system upstream of the Richmond Beach Pump Station (Figure 2). The King County Wastewater Treatment Division (WTD), Shoreline Wastewater Management District (WMD), and Highlands Sewer District (SD) each own and maintain elements of the wastewater conveyance system within the Service Area.

The Hidden Lake Pump Station has a documented firm pumping capacity of 4.2 mgd, but under actual operating conditions the capacity is 3.8 mgd. An 18-inch diameter overflow line leads to Shoreline WMD Pump Station 4, where wastewater can be temporarily stored, pumped back to the Hidden Lake Pump Station, or discharged 365 feet to Puget Sound via a marine outfall. The Hidden Lake Pump Station discharges to a 2,375-foot, long 14-inch diameter force main section of the Boeing Creek Trunk and then by gravity to the Richmond Beach Pump Station. There are numerous connections from Shoreline WMD sewers to the gravity section of the Boeing Creek Trunk, adding flows to the system downstream of the Hidden Lake Pump Station. From the Richmond Beach Pump Station, flow is pumped to the Edmonds Wastewater Treatment Plant.

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[1] The Service Area includes all sewered areas that drain to the KC WTD Hidden Lake Pump Station and all downstream neighborhoods that drain to the Boeing Creek Trunk and Richmond Beach Pump Station. Changes to the size and operations of the Hidden Lake Pump Station designed to fix its problems will also affect these downstream facilities.

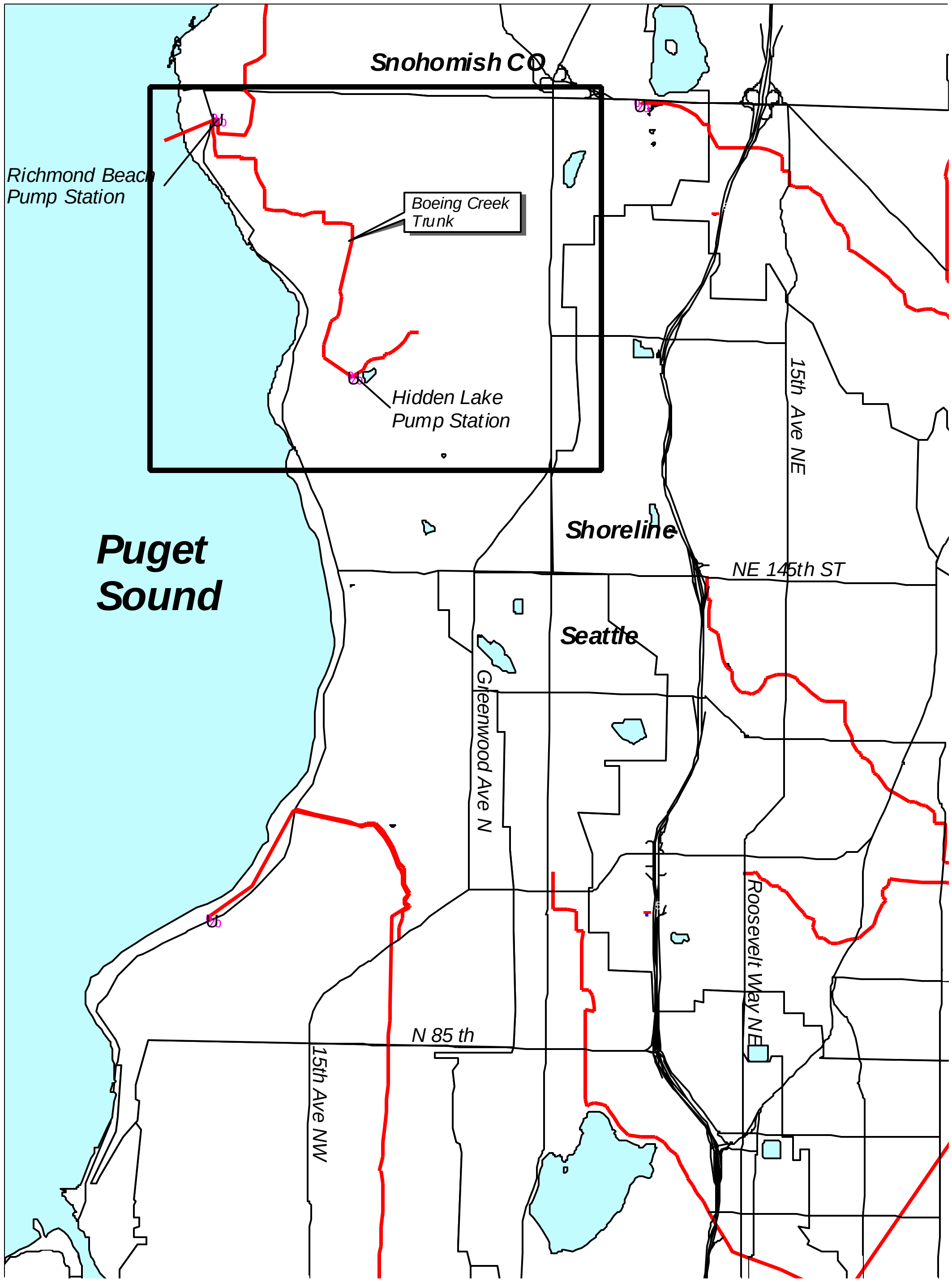

Figure 1: Hidden Lake Service Area
Location and Vicinity Map

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Legend
Road
Pump Stations
King County Conveyance Lines
Waterbodies

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King County Department of Natural Resources

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N W E S

January 12, 1999

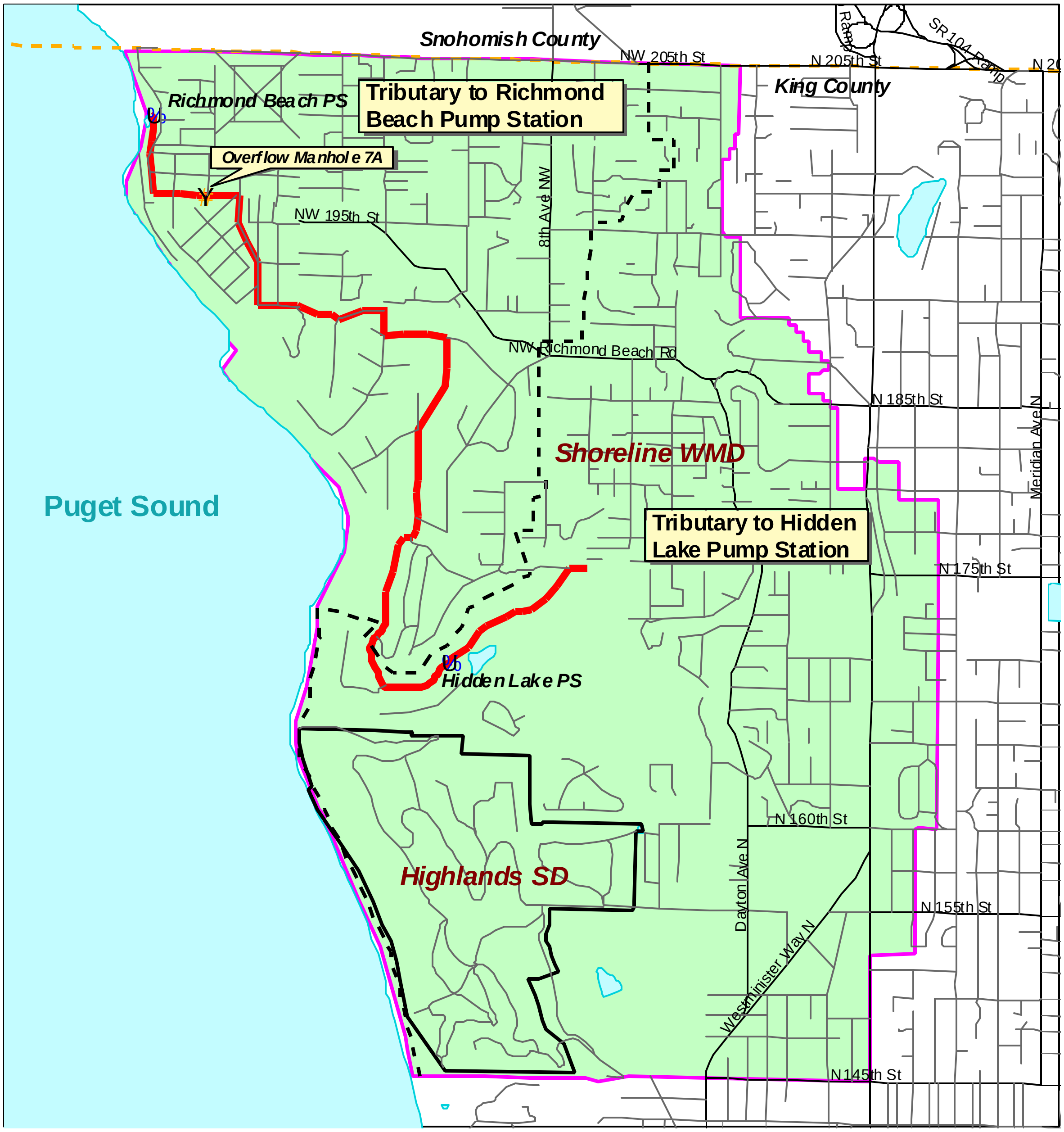

Figure 2: Hidden Lake Service Area

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May 11, 2000

At the time of the Seattle's first comprehensive sewerage plan, the 1958 *Metropolitan Seattle Sewerage and Drainage Survey* (the *1958 Plan*), three sewer systems were serving or about to serve parts of what is today the Hidden Lake Service Area. The Ronald Sewer District had been formed (in 1951) and financed and was planning its system to serve about 1.5 square miles. A second system had been built to serve the proposed Boeing Shopping Center (Aurora Avenue and 160th Street) but was not yet operating. A third system, the Highlands sewer system, collected sewage from a residential neighborhood of 0.7 square miles and discharged that sewage directly into Puget Sound without treatment.

Over the past 40 years, the boundaries and sewerage services provided in the Hidden Lake Service Area have expanded. Today, the entire Service Area is sewered, and a number local agency and King County owned pump stations help transfer wastewater through the system to the Richmond Beach Pump Station and the Edmonds Wastewater Treatment Plant.

Depending on the siting of the North Treatment Plant as proposed by the *Regional Wastewater Services Plan* (*RWSP*) and potential changes to King County's flow exchange program with the City of Edmonds, there may be changes to wastewater conveyance in the Service Area.

TASK 220: WASTEWATER CONVEYANCE FACILITY REVIEW

The Hidden Lake Service Area conveyance system can be summarized as follows:

- Shoreline WMD and Highlands SD collect and transport sanitary sewage to the King County WTD facilities using a network of gravity sewers, lift stations and force mains.
- King County WTD transports sewage along the Boeing Creek Trunk to the Richmond Beach Pump Station. The Hidden Lake Pump Station, located along the Boeing Creek Trunk, assists with flow transfer to Richmond Beach.
- Downstream of the Richmond Beach Pump Station, wastewater flows to the Edmonds Wastewater Treatment Plant, in accordance with King County's wastewater treatment sharing agreement with the City of Edmonds.

Several capacity issues have been identified at the Hidden Lake Pump Station and in the downstream conveyance system. Generally, the capacity of the pump station and downstream facilities is insufficient for wet weather conditions. There are also documented mechanical problems with the Hidden Lake Pump Station. Sanitary sewer overflows at the pump station occur more than once per year due to capacity limitations and/or mechanical failures. Specific areas of concern in the Service Area include:

1. The limited capacity of the Boeing Creek Trunk and the Hidden Lake Pump Station as well as documented mechanical, instrumentation and control, and electrical problems have created backups upstream of the pump station.

2. Two Shoreline pump stations (nos. 4 and 5) transfer wastewater to the Hidden Lake Pump Station. When both Shoreline pump stations are in operation, the flow volumes are sufficient to stress the Hidden Lake Pump Station capacity, regardless of the quantity of influent from the Boeing Creek Trunk.

3. Sulfide-related corrosion and odor have been an on-going problem at the Hidden Lake Pump Station and in the downstream piping.

4. Sliplining sections of the Boeing Creek Trunk has reduced the hydraulic capacity of the system, resulting in an increase in the frequency and severity of storm impacts, including document overflows and backups into the local collection system.

TASK 230: CHARACTERIZATION OF EXISTING CONDITIONS

The design and construction of conveyance facility improvements for the Hidden Lake Service Area must consider the local natural environment. Environment related constraints may make one improvement alternative more costly or less feasible than another. Furthermore, the design of improvements must consider the future development and the related increase in local system wastewater flows. Task 230 examined constraints resulting from the existing environment and the changes in land use anticipated within the Service Area.

Natural Environment

The potentially most significant natural environmental constraints to any conveyance improvement projects within the Service Area would be construction along the Boeing Creek corridor[2], along the Puget Sound shoreline, and the along the bluffs near Richmond Beach/Innis Arden. The Boeing Creek corridor has steep, unstable slopes, seeps, and forested, mature vegetation. Any of these conditions may place significant constraints on construction activities. Construction along Puget Sound could also involve significant permitting and mitigation for shoreline and estuarine wetland disturbance as well. Construction through the bluffs represents challenges related to unstable slopes and potentially significant erosion hazards. These challenges will need to be addressed during the study and design of any projects in the area. Alterations to areas with large stands of trees should also be avoided as much as possible.

[2] The *Boeing Creek corridor* refers to the area along the Boeing Creek surface stream, which should not be confused with the *existing trunk corridor*, or *Boeing Creek Trunk corridor* which refers to the alignment of the Boeing Creek Trunk sewer.

Changes in Land Use

The Service Area is primarily comprised of single family residential units. The Service Area is approximately 100 percent sewered and is presently experiencing less than one percent annual growth. Without changes to the present zoning, there is little room for further growth in most of the Service Area. There is some potential some multi-family development along Aurora Avenue, Richmond Beach Drive, and possibly at Point Wells. According to Shoreline WMD, the local agency sewers have enough excess capacity to handle modest growth. Any growth within the Service Area will increase base sanitary flows to KC WTD facilities such as the Hidden Lake Pump Station and Boeing Creek Trunk (which is important for defining low flow and the range of facility operation).

TASK 240: ALTERNATIVES TO SOLVE HIDDEN LAKE CAPACITY PROBLEMS

Task 240 required the CSI team to develop and evaluate preliminary alternatives for solving the capacity problems within the Service Area, and the mechanical problems at the Hidden Lake Pump Station. The task began by developing flow projections based on population forecasts, and infiltration and inflow (I/I) estimates for the Hidden Lake Service Area for future years. Then, using those flow projections, alternative strategies for reducing overflows to the KC standard of once per 20 years were developed and needed facilities sized. A planning level cost for each alternative was computed, and the costs were compared.

Service Area Flow Projections

KC WTD used observed flows at the Richmond Beach Pump Station along with a more extensive set of flow data from the Lake Ballinger Pump Station to calibration its I/I model[3]. The calibrated model was used to generate projections of the 20-year peak I/I flow. Base flows estimated from population forecasts along with the effects of sewer deterioration[4] were included to estimate the 20-year peak flow in 2050. The 20-year peak flow along the Boeing Creek Trunk was estimated from the locations of major connections from the local system and the contributing sewered area to each of the pipeline sections (Table 1)

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[3] The frequency of overflows upstream of the Richmond Beach Pump Station prevented the gauge at Richmond Beach from recording the full range of flow conditions, making the use of Lake Ballinger Pump Station flow data necessary. After observing the similar rainfall-derived I/I response at the Richmond Beach and Lake Ballinger flow monitors for storms small enough to not produce an overflow, KC WTD was able to assume a hydrologic similarity between the two basins to calibrate its I/I model and generate flow projections.

[4] Sewer deterioration was assumed to result in a 7 percent per decade increase in I/I until 2030.

Table 1. Boeing Creek Trunk existing conveyance capacities and capacity requirements at 20-Year peak flow

Reach	Capacity (mgd)	Base Flow (mgd)	20-Year Peak Flow (mgd)	Additional Capacity Required (mgd) [a]
B00-49 to HLPS	5.9	1.0	8.4	2.5
HLPS to B00-38	3.8[b]	1.3	11.8	8.0
B00-38 to B00-29	7.4	1.5	12.9	5.5
B00-29 to B00-23	5.5	1.5	13.5	8.0
B00-23 to B00-17	6.1	1.9	16.8	10.7
B00-17 to B00-04	9.6	2.0	17.7	8.1
B00-04 to RBPS	7.8	2.1	18.5	10.7

a Based on KC WTD population forecasts for 2050.

b Pump station capacity.

The improvements required to address the problem of insufficient flow capacity must increase the conveyance capacity and/or reduce the flows through these facilities

Development of Conveyance System Improvement Alternatives

As provided for in the scope of work for the project, the CSI project team developed three alternatives for reducing the frequency of conveyance system overflows to once per 20 years. These alternatives are as follows:

A. Upgrading the capacity of conveyance facilities and maintaining current wastewater routing.

B. Using storage to control conveyance system overflows.

C. Diverting peak wet weather flows away from the Boeing Creek Trunk.

Each alternative addresses the replacement, upgrading, and/or construction of new King County facilities, construction factors, planning and permitting issues, planning level costs, and impacts on other King County facilities. Year 2050 flow projections were used in designing these alternatives, where the Service Area is assumed fully developed. Using a 2010 planning horizon would reduce the size of required facilities but would not eliminate the need for additional facilities. The relative costs of the three alternatives to control the 20-year peak flow would not be significantly affected by shortening the planning horizon.

Following completion of the development of the three alternatives, additional alternatives, most of which involve variations on Alternatives A, B, and C, were offered by King County staff. The alternatives considered for the Hidden Lake project are summarized in the following paragraphs.

Alternative A: Upgrading the Capacity of Conveyance Facilities and Maintaining Current Wastewater Routing

The capacity of the conveyance system could be increased by replacing the 37 year old Hidden Lake Pump Station with a pump station approximately three times as large as the existing station, adding capacity to the Boeing Creek Trunk with a new force main and parallel gravity sewer, and retrofitting/upsizing the Richmond Beach Pump Station (see Task 240, Figure 4).

Alternative B: Using Storage to Control Conveyance System Overflows

Alternative B uses storage of peak storm flows as a method of controlling system overflows while limiting the need for upgrading King County facilities. An off-line storage tank could be associated with either the Hidden Lake or Richmond Beach Pump Station. The tank would need to have a capacity of 2.4 MG if the facility were constructed in association with the Hidden Lake Pump Station. A 1.5 MG tank would be needed if it were constructed at the Richmond Beach Pump Station. Additional facility upgrades would be required with either alternative (see Task 240, Figure 5).

Alternative C: Diverting Peak Wet Weather Flows Away from the Boeing Creek Trunk

Alternative C would avoid upgrading some existing facilities by routing peak storm flows away from the Hidden Lake Pump Station and Boeing Creek Trunk. The collection point for the conveyance bypass line would be located at the upstream end of the Boeing Creek Trunk (manhole B00-49). A pump station would be required to move the flows out of the basin. There are two options for sizing the pump station, 8.4 mgd or 11.8 mgd. (These sizes were increased to 9.7 mgd and 13.2 mgd, respectively, using the Task 250 updated flow projections.) Option C1 involves construction of an 8.4 mgd pump station (9.7 mgd in TM250) to intercept the 20 year peak flow at manhole B00-49, above the Hidden Lake Pump Station. In this case, the Hidden Lake Pump Station could remain at its current size, but downstream reaches of the Boeing Creek Trunk would require additional capacity. Alternatively, an 11.8 mgd diversion pump station (13.2 mgd in TM250) could be constructed near manhole B00-49. The Hidden Lake Pump Station effluent would be redirected towards the Boeing Creek Trunk in dry weather or small storms. During large storms, Hidden Lake Pump Station effluent would be pumped to the new diversion pump station and from there towards the Richmond Beach Pump Station. Thus, even during large storms, the Boeing Creek Trunk would not require additional capacity (see Task 240, Figure 6).

Alternative D1: Route Flows to the Lake Ballinger Pump Station

Wastewater could be routed into the McAleer and Lyon basin by a new pump station and a 3-mile long force main/gravity sewer. The new sewer would discharge to the Lake Ballinger Pump Station. With a capacity increase, the Lake Ballinger Pump Station could pump the wastewater to either the Edmonds Wastewater Treatment Plant or the McAleer Trunk, and to the West Point Treatment Plant. The bi-directional pumping capability of the Lake Ballinger Pump Station would provide flexibility to deliver wet weather flows to a new North

Treatment Plant, once a site is determined. Pumping first to the Lake Ballinger Pump Station is an indirect route and requires two pump stations, each with more than 150 feet of static lift. Pumping to the McAleer Trunk would add flow to the Kenmore Interceptor and downstream sections of the King County conveyance system that are already overloaded in wet weather conditions; West Point Treatment Plant would also be affected (see Task 240, Figure 7).

Alternative D2: Route Flows to the Matthews Park Basin

A three and a half mile long force main/gravity sewer could be routed to the southeast to the beginning of the North Lake City Trunk and into the Matthews Beach basin. This would help reduce the number of storm impacts in the Service Area and would add no additional flow to the Edmonds Treatment Plant. Other parts of the King County conveyance system would be stressed. The North Lake City Trunk would require additional capacity to accept the diverted flows. The North Lake City Trunk discharges to the Thornton Creek Interceptor and the Matthews Park Pump Station. Similar to Alternative D1, capacity constraints in the conveyance system and at the West Point Treatment Plant impact this alternative (see Task 240, Figure 7).

Alternative D3: Route Flows Along Beach/Railroad Tracks

A new pressure sewer could be constructed to run towards Shoreline WMD Pump Station 4, then down the bluff near Puget Sound. The pipeline could run northward either along the railroad tracks or the beach to the Edmonds Wastewater Treatment Plant. The wet weather flows could be conveyed to the Richmond Beach Pump Station entirely by gravity, avoiding most major upgrades to Hidden Lake Pump Station and Boeing Creek Trunk. Despite these potential capital cost and operations and maintenance advantages, a number of concerns that make this alternative less attractive. Concerns include King County's past experience with an overflow line down the bluff that was disrupted by land movements. The railroad tracks at the bottom of the bluff run so close to the hillside that pipe construction would have to occur on the west side of the tracks, which borders a wetland with potential salmon habitat. Finally, the deposition of solids along this flat pipeline could result in odors on the beach during summertime, if mitigation measures were not specified during project design (see Task 240, Figure 7).

Alternative D4: Route Flows Through a Deep Tunnel Along NW 175th Street

A pressure sewer could be tunneled underneath NW 175th Street from 6th Avenue NW to 15th Avenue NW, meeting up with the Boeing Creek Trunk near manhole B00-33. This option has the advantage of being more direct than the current Boeing Creek Trunk route, and it would eliminate the need to upsize the Hidden Lake Pump Station. Flows would not be reduced along most of the Boeing Creek Trunk; the tunnel would need to be continued to manhole B00-14. NW 175th Street is a winding residential street, so the tunnel would have several turns. The maximum depth would be approximately 100 feet, requiring deep jacking/receiving pits (see Task 240, Figure 7).

Alternative D5. Using Primary Clarifiers for Storage at the Richmond Beach Pump Station

The Richmond Beach Pump Station was originally a treatment plant, and the project team examined the feasibility of using the primary clarifiers there for storage. As noted in Alternative B2, total storage volume of 1.5 MG would be required at this location, and if a large enough portion of the storage were provided by the clarifiers, there could be a significant cost savings. According to County WTD personnel, the clarifiers were not dismantled during the Richmond Beach Flow Transfer Project, although the top few feet of the vertical walls were probably damaged. However, the clarifiers could provide a maximum storage volume of only 0.2MG, far less than the 1.5 MG of storage required by Alternative B2.

Alternative D6. Redirecting Part of Shoreline WMD Basin 14, Reducing Size of New Pump Station

Alternative C proposed to build a new pump station and force main to convey the wastewater generated in Shoreline WMD Basin 14 to the north and out of the Hidden Lake Service Area. Alternative D6 is similar to Alternative C, the key difference being that Alternative D6 would redirect a portion of the local collection system to connect with the new force main at its gravity transition point. This would reduce the required pumping capacity of the new pump station and size of the force main, resulting in a potential cost savings on these facilities. An examination of a contour map shows that the local topography varies along the proposed diversion route, so that a gravity sewer would need to be constructed relatively deep (see Task 250, Figure 4).

Alternative D7. Tunnel Storage and Conveyance

Alternative D7 proposed to construct a 10- to 14-foot diameter tunnel from either manhole B00-49 or the Hidden Lake Pump Station to the Boeing Creek Trunk in the vicinity of the inverted siphon forebay (B00-29). The tunnel would allow enough storage to control the 20-year design storm at the Hidden Lake Pump Station. The outlet of the tunnel would be regulated in order to limit overflows downstream of its connection with the Boeing Creek Trunk. Constructing a tunnel solely in the public right-of-way would have to consider the many turns of the local streets. A number of access shafts could be dug to allow the tunneling machine to be lifted out of the deep tunnel (greater than 100 feet in places) and reoriented. The density of local housing must be considered for this alternative, because the tunnel would probably have to be constructed partly under private property. The County would need to acquire easements from property owners prior to tunnel construction (see Task 250, Figure 5).

Alternative D8. Interim Solutions to Reduce Overflow Frequency Until the North Treatment Plant has been Sited

As part of a program to manage the 20-year peak flow, this alternative uses a combination of interim remedies to reduce the number of system overflows in the Service Area. The level of sanitary sewer overflow (SSO) control could initially target the once-in-two year or once in five year peak flow. After a site for the North Treatment Plant is chosen, a program of facilities improvements and/or I/I reduction would be implemented to meet the KC standard of one overflow per 20 years. By initially seeking an interim solution that is a part of a phased program of flow management, this alternative would attempt to avoid constructing costly facilities that may be underutilized after the North Treatment Plant is in operation. The planning horizon for this alternative is 2010, rather than 2050 as was used in other alternatives. This date coincides with the scheduled startup date for the North Treatment Plant. An interim solution might include some combination of I/I reduction, inline storage, additional conveyance capacity, and treatment of SSO discharges.

<u>Alternative D9. Phasing Portions of Alternative C Construction on an As-Needed Basis</u>

The regional I/I program will be implemented between winter 2000 and 2004 and will consist of regional flow monitoring and pilot projects to assess I/I impacts on the King County conveyance system. The flow monitoring will refine our understanding of I/I rates in the Service Area; the selected pilot projects will refine our understanding of the cost-effectiveness of I/I removal. The flow data collected during the regional I/I study will help provide greater confidence in the Service Area conveyance system design flows. The location of the North Treatment Plant will affect the sizing and the need for some of the conveyance facilities proposed in various alternatives. By phasing the project, the County would have greater control over the final project costs, and will have the local agency (Shoreline Water Management District) as an integral partner in managing all wastewater flows in the Service Area.

Cost Estimates for Primary Alternatives

Planning level cost estimates were prepared for Alternatives A, B, and C based on cost curves and information gathered from other projects (Table 2). The Boeing Creek Trunk improvements cost estimate takes into account material costs, excavation pits and tunneling, traffic control, and surface restoration as required. The Hidden Lake Pump Station cost estimate includes odor control and chemical dosing. The cost estimate for the Richmond Beach Pump Station expansion is based on the 1991 project cost for pump station construction ($6.25 million). The expansion would increase the pump station capacity by 80 percent; the original cost has been multiplied by 80 percent and a 4 percent annual inflation rate has been applied. The cost of the Richmond Beach–Edmonds Interceptor and force main includes material costs, excavation and trench support, traffic control and surface restoration. A $5.5 per gallon project cost was assumed for the storage tank cost, based on estimating techniques used for King County *RWSP* and combined sewer overflow projects. This cost assumes that a suitable location for the storage tank is available. The odor control and chemical dosing equipment costs are based on previous consultant experience. Land acquisition costs for new pipeline routes (Alternative C) are also included. Costing assumptions include 10 percent for contractor’s operations and profit, 10 percent mobilization/demobilization, 30 percent contingency, 8.6 percent sales tax, and 35 percent for design. These cost estimates also include 50 percent for King County allied costs; these allied costs were not included in the Task 240 report, but are included here to be consist with the Working Alternative cost estimates (see Table 8).

Table 2. Summary of project cost estimates for Alternatives A, B, and C[a]

Conveyance System Improvement Alternative	Cost (million dollars)
Alternative A – Increase conveyance capacity	43.4
Alternative B1 – Offline storage at the Hidden Lake Pump Station	47.0
Alternative B2 – Offline storage at the Richmond Beach Pump Station	41.0
Alternative C1 – Diverting Peak Flows Away from Boeing Creek Trunk with 8.4 mgd Pump Station	43.8
Alternative C2 – Diverting Peak Flows Away from Boeing Creek Trunk with 11.8 mgd Pump Station	38.1[b]

a. These project cost estimates include 10% for contractor's O&P, 10% for mobilization/demobilization, 30% contingency, 8.6% sales tax, 35% for design and 50% KC allied costs. The estimates in this table differ from those in Task 240, Table 17, because the 50% for KC allied costs were not included in Task 240.

b. As the preliminary working alternative, refined cost estimates were developed for Alternative C2. The refinements resulted in a lower estimated cost than in Task 240 (once KC allied costs are added to the Task 240 estimate).

The various Alternatives developed for controlling SSOs in the Hidden Lake Service Area are summarized in Table 3.

At the conclusion of Task 240, the CSI project team selected Alternative C2 (diversion pump station and sewer) and Alternative D3 (waterfront sewer) as working alternatives, and directed that those two alternatives be carried into Task 250 for a preliminary environmental evaluation.

Table 3. Summary of Hidden Lake alternative analysis

Alt. No.	Description	Team Action	Reason
A	Capacity upgrades using existing alignment	Modified	Complete upgrade rejected because of construction difficulties due to buried utilities in right-of-way, but some segments might be upgraded without utility complications
B1	2.4 MG storage at Hidden Lake Pump Station	Rejected	Tank siting problems, higher cost, higher O&M requirements
B2	1.5 MG storage at Richmond Beach Pump Station	Rejected	Does not avoid construction difficulties noted for Alt. A; probability of piling to support tank drives up cost
C1	Diverting flow from Hidden Lake PS w/9.7 mgd pump station (updated size from Task 250)	Rejected	Higher cost than C2 because it requires a new pump station plus upsizing Boeing Creek facilities
C2	Diverting flow from Hidden Lake PS with 13.2 mgd pump station (updated size from Task 250)	Working Alternative	Lowest cost alternative because a larger pump station eliminates need to upgrade Boeing Creek facilities
D1	Pump flow to Lake Ballinger PS	Rejected	Transfers wet weather flows to other maximized/optimized King County conveyance facilities
D2	Pump to North Lake City Trunk and Matthews Park basin	Rejected	Transfers wet weather flows to other maximized/optimized King County conveyance facilities
D3	New sewer over bluff and along shoreline to Edmonds WWTP	Environ. Evaluation	Gravity option a plus, but environmental concerns (ESA, sensitive areas) limit viability
D4	Tunnel new pressure sewer under NW 175th St.	Rejected	Tunnel would be long, deep and have many turns, driving up costs
D5	Use old primary clarifiers at Richmond Beach for storage	Rejected	Storage capacity in clarifiers Insufficient to significantly lower costs relative to Alts. A & B2
D6	Direct part of Basin 14 flows out of Service Area	Rejected	Reduces size of Hidden Lake pump station, but requires long, deep directional drilling
D7	Tunnel storage and conveyance	Rejected	Would require difficult tunnel easements under private property; limiting tunnel to public r-o-w not feasible because of number of street turns
D8	Short term solutions to reduce overflows until North Treatment Plant built	Working Alternative	Controlling 2 year storm requires significant investment now with greater investment required later, but underutilized facilities are avoided and flexibility is maintained
D9	Phase construction on as-needed basis, waiting to see how regional I/I program, North Treatment Plant impact basin	Working Alternative	Can be used with working alternative C or any other alternative to eliminate costs that might not be needed if these programs reduce Hidden Lake problems

TASK 250: ALTERNATIVE EVALUATION, REFINEMENT, AND SELECTION OF A WORKING ALTERNATIVE

Whereas Task 240 involved development of a range of alternatives to solve Service Area conveyance capacity and Hidden Lake Pump Station mechanical problems, Task 250 required refinement of promising alternatives to the point where a working alternative could be selected. Updated flow projections were considered, and the impact of the regional I/I reduction program were discussed. Limitations and impacts of the natural environment were considered. Then a working alternative was synthesized from the various promising alternatives and approaches.

Updated Flow Projections for the Service Area

The capacity analysis described above was based on preliminary flow projections provided by King County. When the Task 240 report was prepared, there was a lack of available local flow data for the local Service Area basins. Since preparation of the Task 240 report, the County obtained and analyzed additional flow monitoring data collected by the Shoreline WMD within Basin 14, upstream of the Hidden Lake Pump Station (Figure 3). The new flow data show that Basin 14 has higher peak infiltration and inflow (I/I) flows that previously assumed. The data do not give any indication whether previous I/I estimates for basins downstream of the Hidden Lake Pump Station were accurate or complete.

The monitored sections of Basin 14 have higher peak I/I rates than the Service Area average of 4,710 gpad for the 20-year. Because not all sections of Basin 14 were isolated by flow monitoring, some basins were assigned I/I rates based on I/I rates in neighboring sub-basins with similar land use patterns. Table 4 gives a new estimate of the 20-year peak flow at the Hidden Lake Pump Station by summing up the peak flows from the individual sub-basins.

Table 4. Comparing peak flows at the Hidden Lake Pump Station

Source	5-Year Peak Flow (mgd)		20-Year Peak Flow (mgd)	
	Year 2000	Year 2050	Year 2000	Year 2050
Task 240 Flows [a]	8.2	9.7	9.9	11.8
Updated Flows	8.2 [b]	9.7 [c]	11.1 [b]	13.2 [c]

a. Data from Task 240 report, Table 1.

b. Flows are summed from Task 250 report, Table 1.

c. Task 250 flow projections for 2050 assume base flow and I/I increase at the rate established in Task 240 (seven percent per decade through 2030).

Basin 1 and 2, located near the Richmond Beach Pump Station, are probably also high I/I areas. The sewers in these basins are among the oldest in the Service Area and published Shoreline WMD data show a strong hydrograph response to rainfall. The time-series flow data were not available for this study, so the 20-year peak flow for these basins has not been estimated.

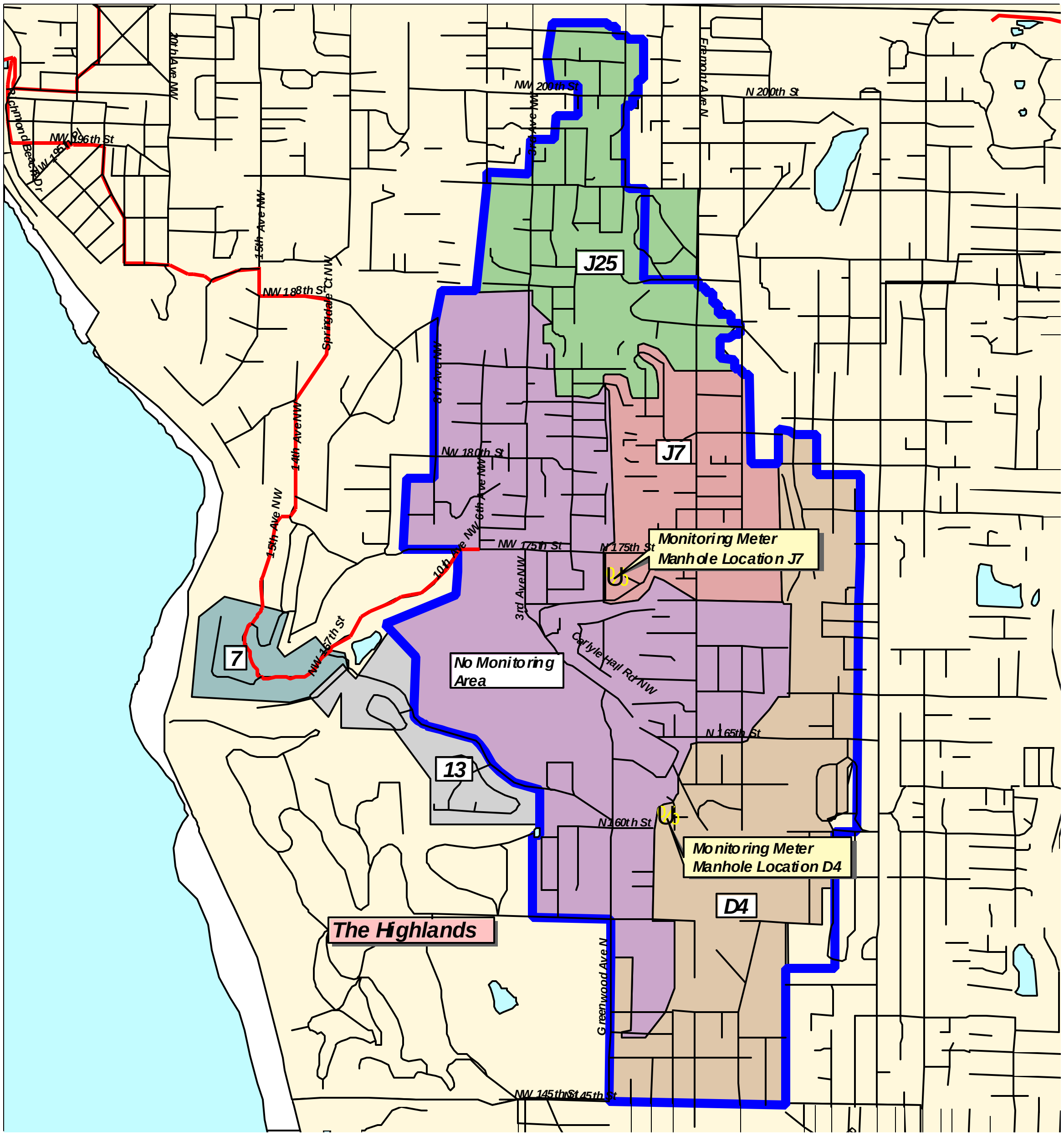

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Figure 3

Hidden Lake PS Portable Monitors

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April 17, 2000

Legend

- Roads
- KC Conveyance Line
- Shoreline WMD Basin 14 Boundary
- Service Basins

Refined Population Projections and Base Flow Projections

The population forecasts used to develop base flows for the Task 240 report were refined in Task 250 by using GIS analysis techniques to sum the population forecasts for the individual Traffic Analysis Zones (TAZ) that are contained in the Service Area[5]. The TAZ population data were provided by the Puget Sound Regional Council (PSRC)[6]. The data source is the same as Task 240, but the analysis here is more detailed. These refined forecasts show that continued slow growth is expected throughout the 50-year planning window (Figure 4, Table 5).

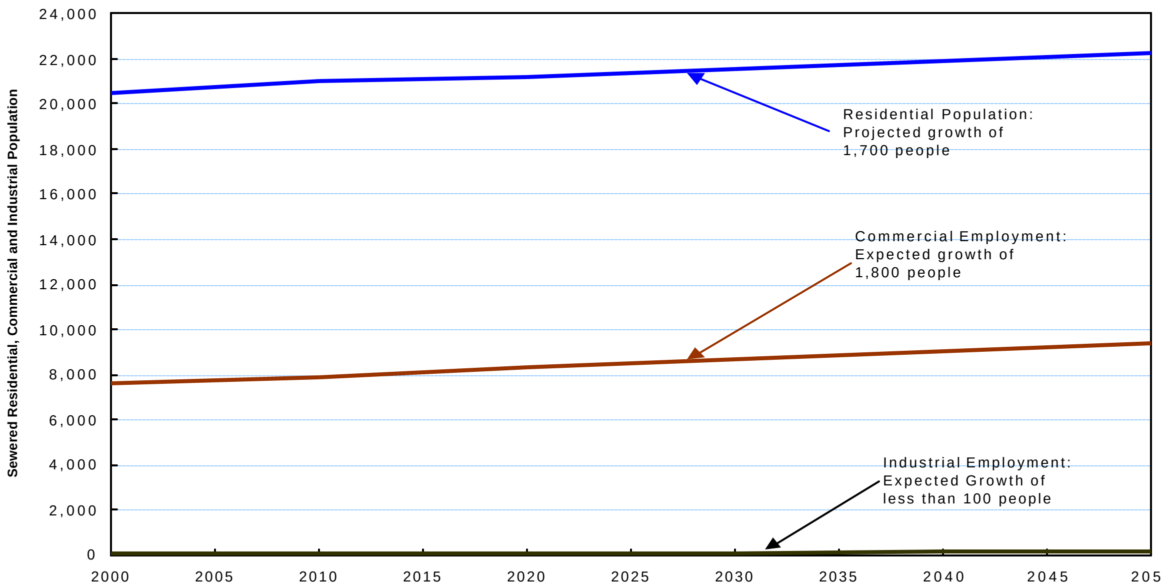

Figure 4. Refined residential population, commercial and industrial employment forecasts for the Service Area.

For comparison with KC WTD forecasts, revised population forecasts for the Service Area were derived from the *1999 Shoreline Comprehensive Plan* (*Shoreline Pla*n) [7] and the draft

[5] For TAZs that span the Service Area boundary, population is calculated (proportionately) according to the fraction of the TAZ within the Service Area

[6] Task 240 used wastewater basin-level forecasts while Task 250 used the more detailed TAZ-level population forecasts.

[7] The planning area considered in the *Shoreline Plan* includes all of the City of Shoreline, plus some potential annexation areas. The City of Shoreline used PSRC's 1998 set of forecasts for its population and employment forecasting. Appendix A of the *Shoreline Plan EIS* presents population forecasts by neighborhood in for a 20-year window beginning in 1996. The stated boundaries were used to determine which of the neighborhoods are located within the Service Area. The population forecasts are expressed in terms of dwelling units (DU), which were converted to population by assuming 2.4 residents per DU.

Shoreline WMD Comprehensive Sewer Plan. The *Shoreline Plan's* forecasted residential baseline population and growth rate is similar to the KC WTD forecasts (Table 5).

Table 5. Refined population forecasts for Service Area[a]

Task 250: Refined KC WTD Forecasts (based on PSRC TAZ data, June 1999)			
Year	**Residential**	**Commercial[c]**	**Industrial[c]**
2000	20,483	7,572	66
2010	21,019	7,840	70
2016	21,098[b]	8129[b]	81[b]
2020	21,151	8,322	88
2030	21,549	8,664	99
2040	21,885	9,038	110
2050	22,218	9,413	120
Task 250: 1999 Shoreline Plan Forecasts			
Year	**Residential**	**Commercial**	**Industrial**
1996	18,418	N/A	N/A
2000	18,899[b]	N/A	N/A
2016	20,822	N/A	N/A
Task 250: Draft Shoreline WMD Comprehensive Sewer Plan Forecasts[d]			
Year	**Residential**	**Commercial**	**Industrial**
2000	19,919	N/A	N/A
2016	21,569	N/A	N/A
2020	21,981	N/A	N/A

a. These forecasts are for the entire Service Area: neighborhoods that drain to the Hidden Lake Pump Station and downstream neighborhoods served by the Richmond Beach Pump Station.

b. The reported residential population is linearly interpolated from previous and following time periods in order to provide easy comparison to the other forecasted data set.

c. KC WTD's commercial and industrial population is based on the PSRC's forecasting by U.S. Dept. of Labor Standard Industrial Classification (SIC) codes using Washington State Employment Security Department records.

d. The draft Shoreline WMD Comprehensive Sewer Plan dated May, 3, 2000, reported forecasted residential populations of 36,151 and 39,941 for 2000 and 2020 for the Shoreline WMD coverage area. The baseline population is based on the number of Residential Customer Equivalents (RCE) recorded by the District, and the growth rate is based on PSRC's 1995 TAZ study. The populations shown above have been computed using the fraction of the Service Area within Shoreline WMD coverage area (assumes uniform spatial population distribution), plus 245 residents for the Highlands (102 DU and 2.4 people per DU).

The KC WTD population forecasts were compared with *Shoreline Plan* and Shoreline WMD forecasts included for the area tributary to the Hidden Lake Pump Station. The Shoreline WMD forecasts ranged from 8 to 17 percent higher than the KC WTD forecasts between

2000 and 2020, with the largest difference occurring in 2020 (12,914 by Shoreline WMD; 11,024 by KC WTD). The difference may result because the GIS-based, TAZ analysis used to develop the KC WTD forecasts is less accurate for smaller areas, and because the Shoreline WMD faced difficulties applying population forecasts from available sources because the areas covered by these forecasts were not coincident the District boundaries.

Impacts of Infiltration and Inflow Reduction

The project team examined the potential impacts of infiltration and inflow reduction for the Service Area. Two I/I reduction scenarios were examined:

1. A 30 percent basin-wide reduction in the peak 20-year I/I as a benchmark based on the goals of the KC regional I/I program.

2. A higher level of targeted I/I reduction for its effectiveness in limiting the number of new facilities to be constructed.

Infiltration and inflow account for about 86 percent of 5-year peak flow and 89 percent of the 20-year peak flow in the Hidden Lake Service Area’s wastewater conveyance system, based on the projections of King County's calibrated I/I model (see Table 6). During wet season storms, the capacity of the existing conveyance facilities are periodically exceeded, resulting in sanitary sewer overflows (SSOs). According to the County, there is currently an average of three SSO events each year at the Hidden Lake Pump Station wet well[8]. Downstream of the Hidden Lake Pump Station, there is a designed overflow at manhole 7A of the Boeing Creek Trunk, and there have been reports of overflows at other manholes along the trunk (see Task 210 report).

Table 6. I/I contribution to peak flows at the Richmond Beach Pump Station[a]

	Peak Flow (mgd)	I/I Flow (gpad)	I/I Flow (mgd)	% Attributable to I/I
5-Year Storm Event	15.2	4,530	13.0	86%
20-Year Storm Event	19.9	6,160	17.7	89%

a The flow projections were provided by KC WTD for the year 2050. Their estimates assume a seven percent per decade increase in I/I for the decades through 2030. The updated flow projections from the previous section are incorporated upstream of Hidden Lake. The flow projections downstream of Hidden Lake were not updated because no additional flow data were collected or analyzed for this part of the collection system.

8 This estimate includes hydraulic capacity related overflows and overflows resulting from mechanical failures. Hidden Lake Pump Station overflows are directed to Shoreline WMD Pump Station No. 4, where approximately 75 percent are controlled and pumped back to the Hidden Lake Pump Station. The other 25 percent of overflows discharge to Puget Sound.

Table 7 shows the projected 20-year peak flow at the Hidden Lake and Richmond Beach Pump Stations and along the Boeing Creek Trunk without I/I reduction and following a 30 percent reduction of I/I.

Table 7. Impact of I/I reduction on existing facilities

Reach	Length (ft)	Design Flow[a] (mgd)	20-Year Peak Flow (mgd)	20-Year Peak Flow After 30% I/I Red. (mgd)	Excess Flow (mgd)[c]
B00-49 to HLPS	2,803	5.9	11.9	8.4	2.5
HLPS to B00-38	2,375	3.8[b]	13.2	9.2	5.4
B00-38 to B00-29	2,476	7.4	14.3	10.0	2.6
B00-29 to B00-23	3,316	5.5	14.9	10.4	4.9
B00-23 to B00-17	2,260	6.1	18.2	12.7	6.6
B00-17 to B00-04	3,718	9.6	19.1	13.4	3.8
B00-04 to RBPS	872	7.8	19.9	13.9	6.1
RBPS	N/A	10.4	19.9	13.9	3.5

a. Design flow calculated with Manning's equation using friction factor, n = 0.013

b. Equal to the pumping capacity of the Hidden Lake Pump Station.

c. Excess flow after 30 percent I/I reduction.

As Table 7 shows, removing 30 percent of peak wet weather I/I would help reduce the frequency of overflows but would not control the 20-year storm. With a 30 percent reduction in peak I/I, new facilities would still be necessary. Targeted I/I reduction could be used with other control strategies to delay some construction. An accurate estimate of the costs of this level of rehabilitation cannot be developed without extensive flow monitoring, source detection, and the development of unit costs for I/I removal, such as will be provided by the KC regional I/I program.

Selection of a Working Alternative

The consultant team was instructed to prepare alternatives that involved phased construction and combinations of demand management, storage and increased conveyance. The additional phased/combination alternatives were presented to KC staff at a decision workshop held on March 16, 2000. The objective of the workshop was to specify a working alternative that would meet the immediate upgrade needs at the Hidden Lake Pump Station, reduce the number of sanitary overflows in the service area, and achieve the KC 20-year control level.

The workshop began with a description of the current level-of-service problems in the Service Area, a review of future flow projections, and a recap of the alternatives that had been previously developed. Following the review of previous work, additional alternatives emerged by combining the following elements:

- Increasing the conveyance capacity along the existing corridor

- Incorporating storage to attenuate peak flows
- Managing demand by reducing I/I and/or reducing the amount of sewer deterioration
- Constructing a pump station and diversion sewer to carry peak flows away from the Boeing Creek Trunk

Working Alternative Description

The working alternative would initially retrofit or replace the Hidden Lake Pump Station to achieve a peak pumping capacity of 5.5 mgd[9], and parallel or replace a total of 6,400 lineal feet of the most capacity limited sections of the Boeing Creek Trunk. Increasing the pumping capacity at Hidden Lake and removing the bottlenecks in the Boeing Creek Trunk would allow the full capacity of the 10.4 mgd Richmond Beach Pump Station to be used. This combination of upgrades would reduce the number of storm related overflows to approximately one every 2 years. Providing 0.5 MG of storage upstream of the Hidden Lake Pump Station would, according to the best available flow information, further reduce the number of storm related overflows to one every 4 to 5 years. After the North Plant siting and regional I/I programs are completed (assumed 2005), the level of control would be brought to the KC standard of one overflow every 20 years by I/I reduction, additional storage and/or construction of a diversion pump station and sewer directed away from the Boeing Creek Trunk. The final flow projections and treatment plant location would be used for sizing and alignment of the new facilities.

This alternative provides:

- Short-term improvements that will reduce the frequency of overflows and long-term improvements will incorporate better flow projections and routing information.
- Time for the regional I/I program to work. Rather than accepting all flows from the component agencies, the County can work with these agencies to promote I/I control and system maintenance to manage peak flows.
- Expanded capacity in the Boeing Creek Trunk that will allow the Richmond Beach Pump Station to be fully utilized.

The decision to retrofit the Hidden Lake Pump Station or replace it with an adjacent pump station (possibly where the driveway is currently located) will be made after performing a

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[9] Increasing the capacity of the Hidden Lake Pump Station from 3.8 mgd to 5.5 mgd and upgrading the downstream conveyance brings the capacities of these facilities in line with the Richmond Beach Pump Station. Both upgrades are essential to reducing overflows until the 20-year control plan is implemented. Increasing the capacity of the trunk sewer will reduce overflows at manhole 7A. Rebuilding or retrofitting the Hidden Lake Pump Station with a 5.5 mgd capacity will reduce the frequency of overflows from the wet well, while limiting force main velocities to 8 ft/s. All facilities would have sufficient capacity for the unattenuated 2-year peak flow.

detailed analysis in project predesign. The predesign team must investigate if larger pumps that meet the new design head and flow conditions could fit within the existing layout, and if these pumps could pump slowly enough to pass dry weather flows with continuous operation (i.e. alleviate current cycling problem). New electrical, instrumentation and control equipment will be necessary whether retrofitting or replacing the station. The amount of work involved and the necessity of maintaining operation of the pump station during construction may require that the existing station to be replaced. The cost estimates prepared in this section assume the Hidden Lake Pump Station is replaced with a new pump station.

If a new station is built, the design team must work closely with KC operations and maintenance staff to avoid the major operating constraint of the current station. During low flow periods, the small size of the wet well and range of operation of the pumps cause the pumps to frequency cycle on and off. This problem could be minimized by incorporating storage in the influent portion of the Boeing Creek Trunk, and choosing pumps that can operate slowly enough to continuously pump dry weather low flows. The existing overflow/relief sewer orientation would also have to be changed. Currently, the wet well influent from Shoreline Pump Stations No. 4 and No. 5 also forms the wet well overflow (see Figure 5). Backflow into this line would have to be eliminated by either reorienting the piping or installing an appropriate valve. A new pump station overflow/relief sewer could be installed in the upstream piping. All local connections were previously removed from the Boeing Creek Trunk, so locating the relief structure upstream of the pump station will not affect service to local customers so long as the overflow piping is large enough to prevent backups beyond manhole B00-49.

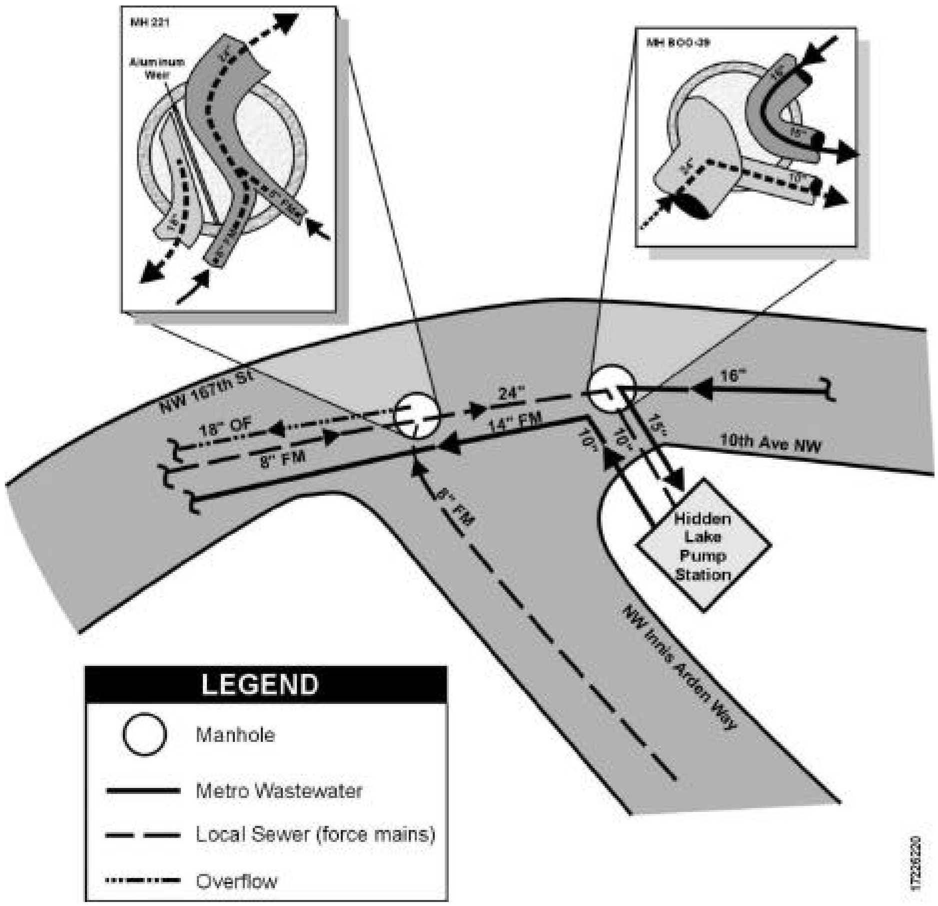

Figure 5. Influent, effluent and overflow piping in the vicinity of the Hidden Lake Pump Station

Figure 6 shows projected peak flows, current and pre-sliplining conveyance capacities along the Boeing Creek Trunk. The paralleling/replacement work is planned for the pipe segments between manholes B00-29 to B00-17 and B00-7 to the Richmond Beach Pump Station. These pipes are shown in the figure as not having enough capacity to pass the 2-year peak flow (see Figure 7 pipe locations).

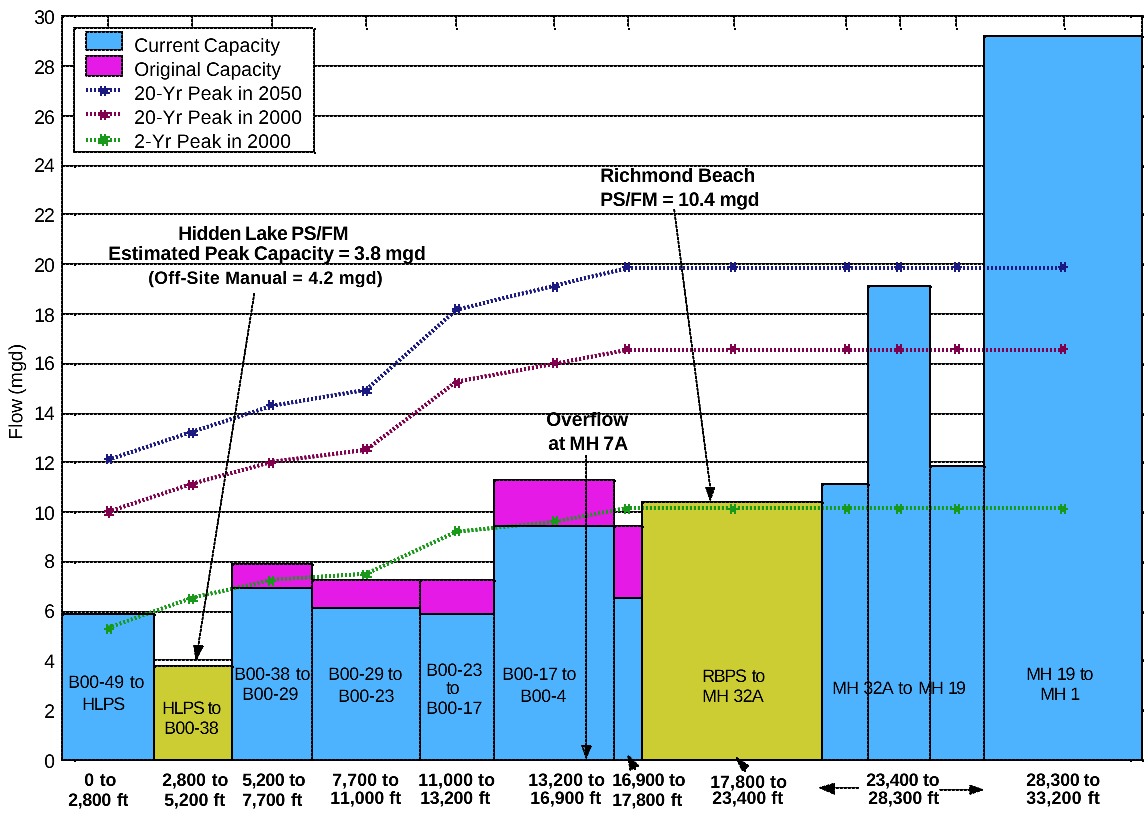

Figure 6. Peak flows and conveyance capacity in the Boeing Creek Trunk.

The CSI project team has performed a preliminary analysis of where the 0.5 MG of storage could be located. The relatively small, flat portion of the Hidden Lake Pump Station property would probably not be large enough to contain a 0.5 MG storage tank. If the new pump station is built adjacent to the existing pump station[10], the existing station's dry pit could be converted to storage after the new pump station is online, but this would only accomplish a small fraction of the 0.5 MG needed. One potential location for offline, gravity in/out storage is along NW 175th Street, between 6th and 10th Avenues NW. A storage tank and associated piping could be located on a section of the vacant property on the northwest corner of NW 175th Street and 6th Avenue NW. Alternatively, an 8-foot diameter offline pipe could be installed from B00-49 to B00-42 (Figure 7). This pipe would measure 1,450 feet in length and would contain approximately 0.5 MG of storage volume. These examples are included to illustrate that storage upstream of Hidden Lake is possible. The location and alignment of storage elements must be examined in greater detail during project predesign.

[10] Building the new pump station adjacent to the existing pump station would allow the current station to continue operating during construction.

Table 8 and Figure 8 show cost estimates for both phases of the working alternative. The component costs shown for phase I of the project are Brown and Caldwell estimates and include 10 percent for contractor's operations and profit, 10 percent mobilization/demobilization, 30 percent contingency, 8.6 percent sales tax, and 35 percent for design. The phase II costs assume additional facilities are a diversion pump station and sewer sized to provide enough additional capacity to convey the 20-year peak flow.

Table 8. Working Alternative cost estimate

	Cost (millions; ENR=7,000)
Project Phase I:	
Replace Hidden Lake PS at 5.5 mgd	3.3[a]
Parallel/Replace 6,400 ft of Boeing Creek Trunk (brings control to 2-year level)	4.0[a]
Add 0.5 MG of storage upstream of Hidden Lake PS (brings control to 4 to 5-year level)	2.8[a,b]
Add KC allied costs (assume +50%)	+50%
Phase I Total	**15.1**
Project Phase II:	
Add facilities (brings control to 20-year level; KC allied costs included)[c]	20.5
Total Project Cost:	**35.6**

a. Brown and Caldwell estimates include 10% contractors O&P, 10% mob/demob, 30% contingency, 8.6% sales tax, and 35% design and owner management. These costs assume the Hidden Lake Pump Station is replaced, not retrofitted.

b. Construction costs in the congested area downstream of the Hidden Lake Pump Station have been increased by 50% to reflect the potential difficulties of design and construction in areas with large numbers of buried utilities.

c. Assumes diversion pump station and sewer sized to bring control to 20-year level with no I/I reduction, and a 7% increase in I/I per decade for 3 decades through 2030.

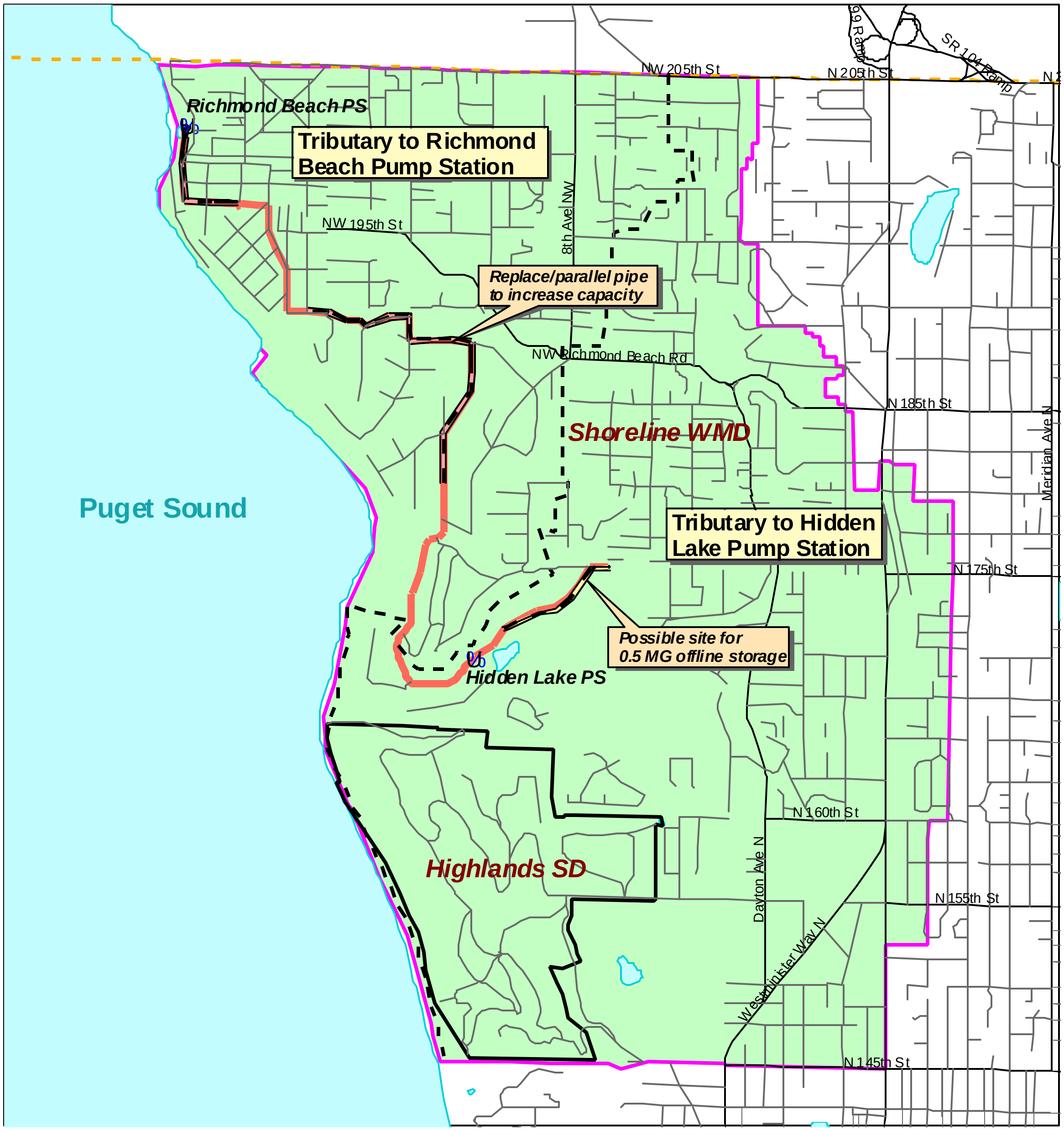

Figure 7: Working Alternative Phase I

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0.1 0 0.1 0.2 0.3 Miles

May 11, 2000

Legend
- Off-line storage pipe
- KC Pump Stations
- Sections to Replace/Parallel
- County Boundary
- Boeing Creek Trunk
- Hidden LK Service Area

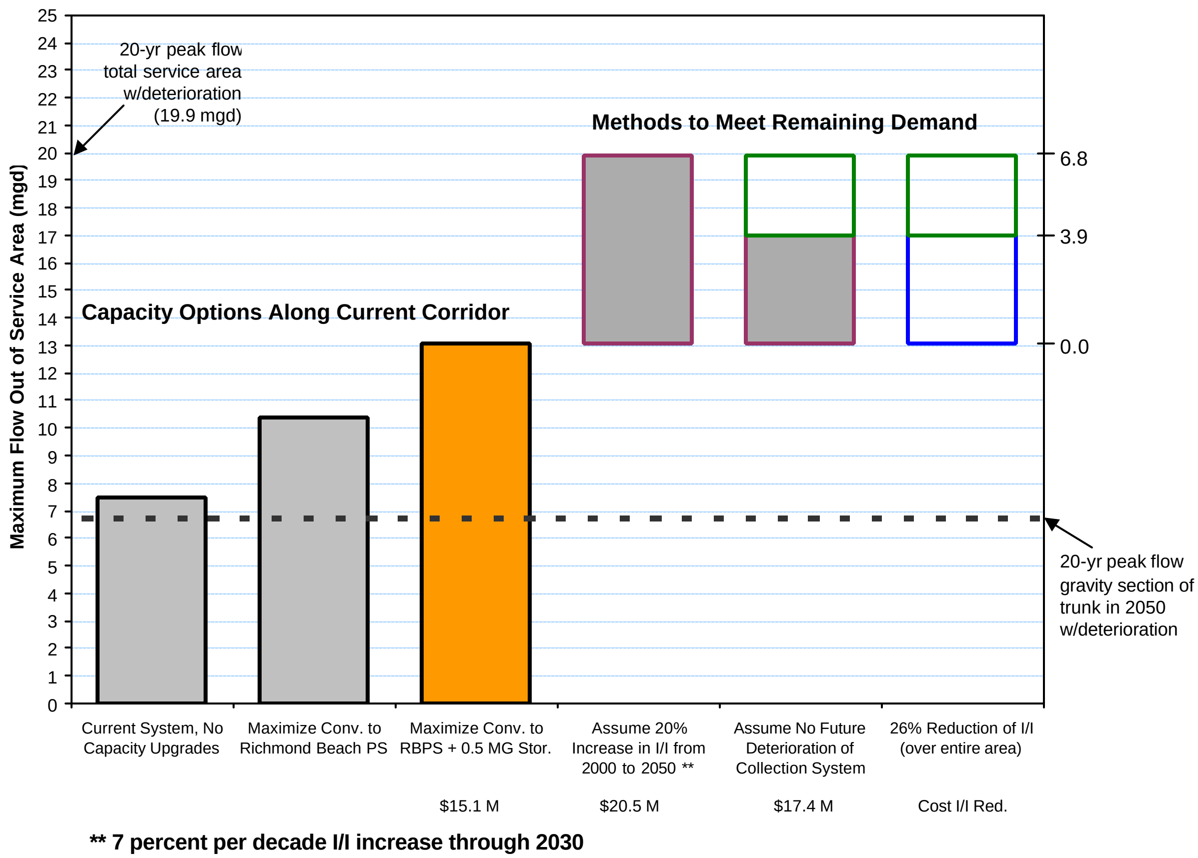

Figure 8. Distribution of costs for interim and future facilities upgrades in the Service Area